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A Large Reinforced-Concrete Dome on a Church in Los Angeles, Cal.

The church shown partially completed in Fig. 1 of this article is the Second Church of Christ, Scientist, recently erected in Los Angeles, Cal. It is of reinforced-concrete framework, faced with white enamel brick and terra-cotta and is surmounted with a large reinforced-concrete dome, the design and construction of which are somewhat out of the ordinary. The main portion of the structure follows the standards of beam and girder construction, modified in parts by the peculiar layout necessary to the auditorium, but the dome construction is entirely independent of the remainder of the structure except as the roofs of the wings connect with the bottoms of the large girders at the base of the dome proper, a connection that may be seen on Fig. 1.

The dome, approximately hemispherical in shape, is carried directly to the ground on four columns, the corners of a 70-ft. square. These columns carry, as sides of the square, four girders, which in turn carry at their corners four other smaller girders, these eight girders forming the sides of an octagon. The angles of this octagon are then crossed by eight other beams, the top of all the girders forming then an equilateral 16-sided figure on which the circular base of the dome rests. These columns and girders are all of concrete reinforced with riveted steel shapes joined together to form one stiff unit.

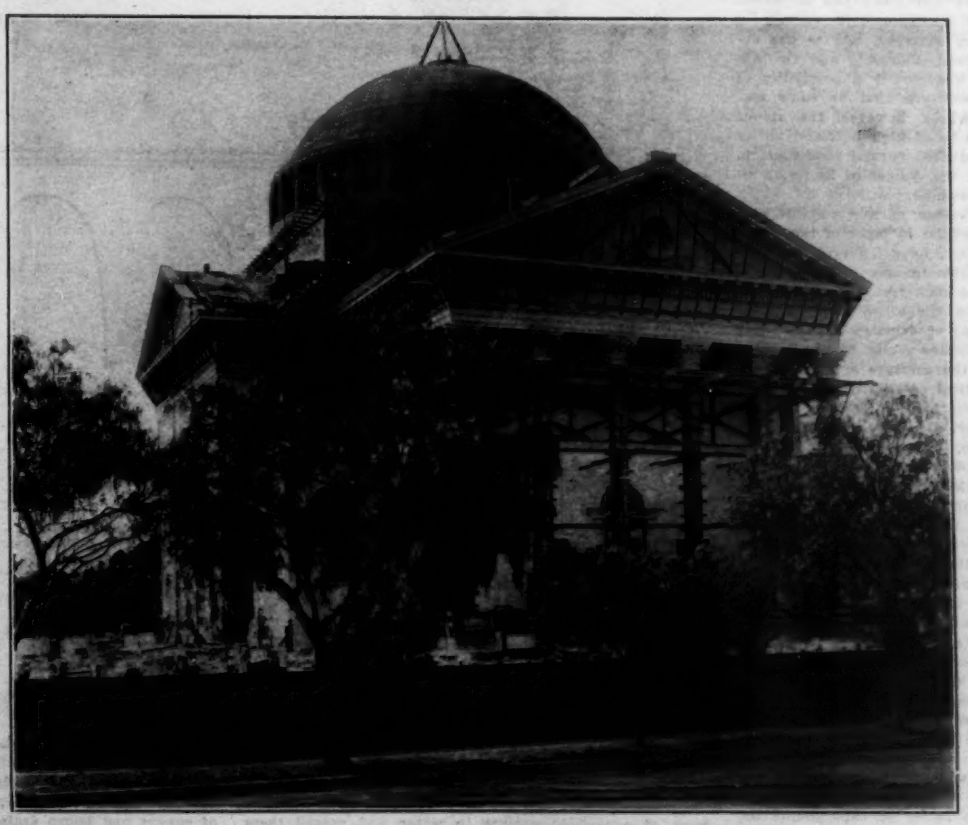

FIG. 1. THE SECOND CHURCH OF CHRIST, SCIENTIST, LOS ANGELES, CAL. A REINFORCED-CONCRETE FRAME AND DOME.

Each of the four basic columns (Fig. 3) has for reinforcement four 3 × 3 × ⅜-in. angles on the corners of a 28-in. square, double latticed with 2½ × ¼-in. bars and strengthened with three 3 × 3 × ⅜-in. T-bars at the outside corner of the section. These T-bars are shown in the elevation on Fig. 3 but not in the plan. Between these columns extend the four main girders, which are the heaviest part of the entire construction. These girders are of concrete reinforced with a structural steel truss and extra round rods. Each girder is 70 ft. 3 in. c. to c. of columns, 20 ft. deep at the column and 10 ft. deep at the middle, and 1 ft. 4 ins. thick. The reinforcement, shown in Fig. 3, consists of a steel truss with upper and lower chords of 6 × 6 × ⅝ and 6 × 4 × ⅝-in. angles, with verticals of 3 × 2½ × 5/16-in. angles and diagonals of 3 × 5/16-in. bars, all riveted together at joints and riveted at the ends into the structural steel work of the columns. In addition there is bar reinforcement as shown. The girders which span the corners of the main girders, Fig. 3, are 29 ft. 8 in. span, and rest on brackets half way up the main girders so that the top angles of all eight girders are on the same level. The smaller girders are also reinforced with angles and rods, the former riveted into the framework of the main girders at connecting points. The details of the eight small beams are not shown in the drawings but the position and size of these beams may be seen in the half-tone in Fig. 5.

In construction the steel work for the whole structure up to the small beams was progressively erected and then the concrete was laid around it in forms supported by the steel work. This stage of the construction is shown in Fig. 4. In concreting these supporting girders and beams, bolts were placed which were afterward used to hold the base of the timber ribs which were used for the forms for the dome. These ribs are shown in Fig. 5 resting at their base on the finished concrete and at their common center at the top on a timber tower. The rough boarding of the form for the dome was made up in sections and hoisted into position. The first section of the dome (Fig. 2) consists of a 3-ft. ring 16 ins. thick, bearing on the beams, girders and trusses and reinforced on the bottom with two 1-in. bars and on the outer face with six 1-in. bars. The next section of the dome as constructed consisted of the 32 columns and a horizontal circular ring connecting the tops of these columns (Fig. 5). The columns have a minimum section of 12 × 14 ins. and are reinforced with four ¾-in. twisted bars wrapped spirally with No. 6 wire spaced 2½ ins. on centers, the ends of the bars projecting six or eight inches into the lower and upper rings. The upper ring is 16 ins. deep and about 28 ins. wide and is reinforced with five 1-in. twisted bars on its outer face. The shell of the remainder of the dome rests on this upper ring or girder and is 8 ins. thick at the base and 4 ins. at the crown. The horizontal reinforcement consists of ¼-in. twisted bars spaced 6 to 12 ins. on centers while the same size bars were spaced 18 ins. on centers in the opposite direction. Galvanized wires were embedded in the concrete for anchoring the brick and terra-cotta facing, and as all this work was grouted with concrete, a very strong bond was secured.

The dome is shown in Fig. 2. In this view is also shown a superimposed timber shell on top of the concrete dome, which was added by the architect after construction had commenced, to make a more pleasing curve than the one originally designed and, at that time, partially erected.

The concrete for the piers, girders and dome was hoisted in a bucket to a point 30 ft. above the highest part of the work, and from these was led in a 7-in. sheet-iron, swivel-joined pipe to any part of the structure desired. The forms for the dome were allowed to remain 90 days after pouring, during which time all of the exterior terra-cotta had been laid. When the cen-

ters were struck the dome deflection was only 1/16-in., the large truss deflections were between ¼ and ⅝-in.

A. F. Rosenheim is the architect of the building; the concrete work was constructed according to the design and under the supervision of Alfred C. Martin, both of Los Angeles. The C. J. Kubach Co. is the contractor.

The Sanitary Significance of Bacteria in the Air of Drains and Sewers.*

By C.-E. A. WINSLOW.†

The idea of the connection between sewer gas and disease dates back to the days when the cause of the infectious maladies was still unknown. Mysterious miasmatic influences were naturally enough supposed to accompany the foul odors of decomposing organic matter. When it was proved that the contagious and infectious diseases are due to the presence of microscopic plant and animal parasites, the case against sewer gas seemed less convincing.

Nägeli and many other bacteriologists showed that under ordinary conditions germs adhere strongly to moist surfaces and are not easily given off from liquids into the adjacent air. Sir Edward Frankland in England and Raphael Pumpelly in this country carried out experiments which indicated that chemicals in solution, and bacteria in suspension, might be thrown into the air from liquids by the bursting of bubbles. On this contingency the possible danger of sewer gas infection still might rest.

Actual examinations of the air in sewers, however, by Miquel in France, Petri in Germany and Carnelly and Haldane, Robertson and Laws and Andrewes in England showed that sewer air as a matter of fact contains very small numbers of bacteria and those of types common in street air rather than in sewage. Uffelmann found the same condition in the air of a house drainage system. Carnelley and Haldane and Laws and Andrewes isolated sewage bacteria in the immediate vicinity of points where active splashing occurred. As in the experimental studies of Frankland, Pumpelly and Dr. Abbott, of Philadelphia, there was clearly a possibility of air infection where spray was produced by some mechanical method. On the whole, however, the air of drains and sewers seemed to be of high bacterial purity and all the observers who studied normal conditions in actual sewers concluded that the danger of bacterial infection from sewer air was remote.

These results, with the absence of any reliable evidence from the study of epidemics in favor of the transmission of germs by sewer air, have led sanitarians in Germany and the United States to agree with practical unanimity that the danger of such transmission may be disregarded. In England, on the other hand, a large number, probably a majority, of sanitary experts have failed to be convinced, and have clung to the opinion that under some conditions the carriage of disease bacteria by sewer air is a practical possibility.

A little over a year ago,‡ at the request of the National Association of Master Plumbers, I made some experiments on this problem, upon which no practical investigations had been conducted for over ten years. I used an experimental stack of 4-in. soil pipe, 15 ft. in height, with a running trap at the bottom and an exhaust fan, for drawing up a strong current of air, at the top. Sewage was placed in the trap, sealing it partially or completely, or resting in the bottom without sealing it. Air was drawn over the sewage and wetted surfaces of the pipe or was bubbled through the sealed trap and the air was examined at various points in the stack above. When the air current was strong, an increase was noted in the bacterial content of the pipe air; but the increase was not striking even at high velocities and was entirely wanting with air currents of less extreme force. Only three of the characteristic bacteria of sewage were isolated from the air in the whole series of experiments. As a result of this investigation I reported that the danger of bacterial infection from drain air was but slight.

At about the same time a series of experiments on sewer air was reported to the Royal Society of London by Major W. H. Horrocks of the English Army Medical Corps. His results seemed at first sight to warrant widely different conclusions from those drawn by other observers; and it seemed necessary to re-examine the whole question with the greatest care.

Major Horrocks' general method consisted in the artificial infection of the lower part of natural and experimental drainage systems with a peculiar bacterium, the Bacillus prodigiosus, which is not normally found in the air. He then exposed small open dishes of nutritive media (Petri plates) in the upper part of the systems. Germs carried up in the air fell on the plates, grew and developed into visible colonies, and among these colonies he identified the particular form, B. prodigiosus, introduced in the liquid at the bottom. By this process he detected his test organism in a pipe 9 ft. above an experimental running trap into which it had been introduced, and in the air of a catch basin of the town into which he had poured it. Similar results were obtained when the lower sections of his experimental pipe system were wetted with a culture of the B. prodigiosus and then dried. The dried germs were apparently detached, carried up by the air and deposited on the plates. In another series of experiments sewage, infected with the typhoid bacillus or with B. prodigiosus, was allowed to flow, quietly and without splashing, through a horizontal pipe to which a vertical pipe was connected at an intermediate point. Plates exposed in the vertical pipe showed colonies of the specific bacteria introduced below, even at a height of 11 ft. 9 ins. above the liquid. Again, emulsions of B. prodigiosus were flushed from the closets of drainage systems in actual use and the germs thus introduced were found in all parts of the systems in open connection therewith, even at a height of 50 ft. above the traps. Major Horrocks, by the same method of exposing Petri plates, found Bacillus coli, the characteristic organism of sewage, in a house drain and in the main sewer of the town. Finally, he suspended the feces of a typhoid patient in water and passed them through a half-S-trap and found the typhoid organism on plates in a vertical pipe above at a height of 3½ ft. above the liquid.

Major Horrocks' report, and a still more recent series of confirmatory experiments by Dr. F. W. Andrewes, of London,* naturally excited the deepest interest among sanitarians. In many quarters the old suspicions of sewer air were revived in almost their full force.

The Journal of the American Medical Association, for example, said, in commenting upon Horrocks' work: "We may still have to look to sewer emanations as the occasional cause of mysterious outbreaks of disease." Other sanitarians maintained a more conservative attitude, and waited further evidence before abandoning their previous conclusions.

The matter stood about as follows: On the one hand Horrocks had shown that specific bacteria, present in traps and drains, could get into the air above by splashing, by the bursting of bubbles and even in some experiments from the surface of liquids apparently in quiet motion; he detected such bacteria by the plate method in the air of ventilating pipes at considerable distances (once at 50 ft.) above the infected liquid. On the other hand, Miquel, Petri, Uffelmann, Carnelly and Haldane, Laws and Andrewes and others had shown that the number of bacteria actually present in the air of sewers and house drains is extremely small and that those present are generally air forms and not sewage forms. Furthermore, reliable evidence of the spread of infectious disease by sewer air is wholly lacking. The inconsistency of the two sorts of evidence required explanation; and, after presenting the facts to the Sanitary Committee of the National Association of Master Plumbers, I was commissioned by them to attempt the clearing up of the apparent contradiction.

I first attempted to repeat as closely as possible one of Horrocks' simpler experiments. I examined the air of a boat chamber on one of the main sewers of the city of Boston, as Horrocks had done in the sewers of Gibraltar. I found colon bacilli, the characteristic sewage organism, on my plates in many experiments; but their number was least nearest the sewage, greater nearer the street, and greatest in the street air itself.

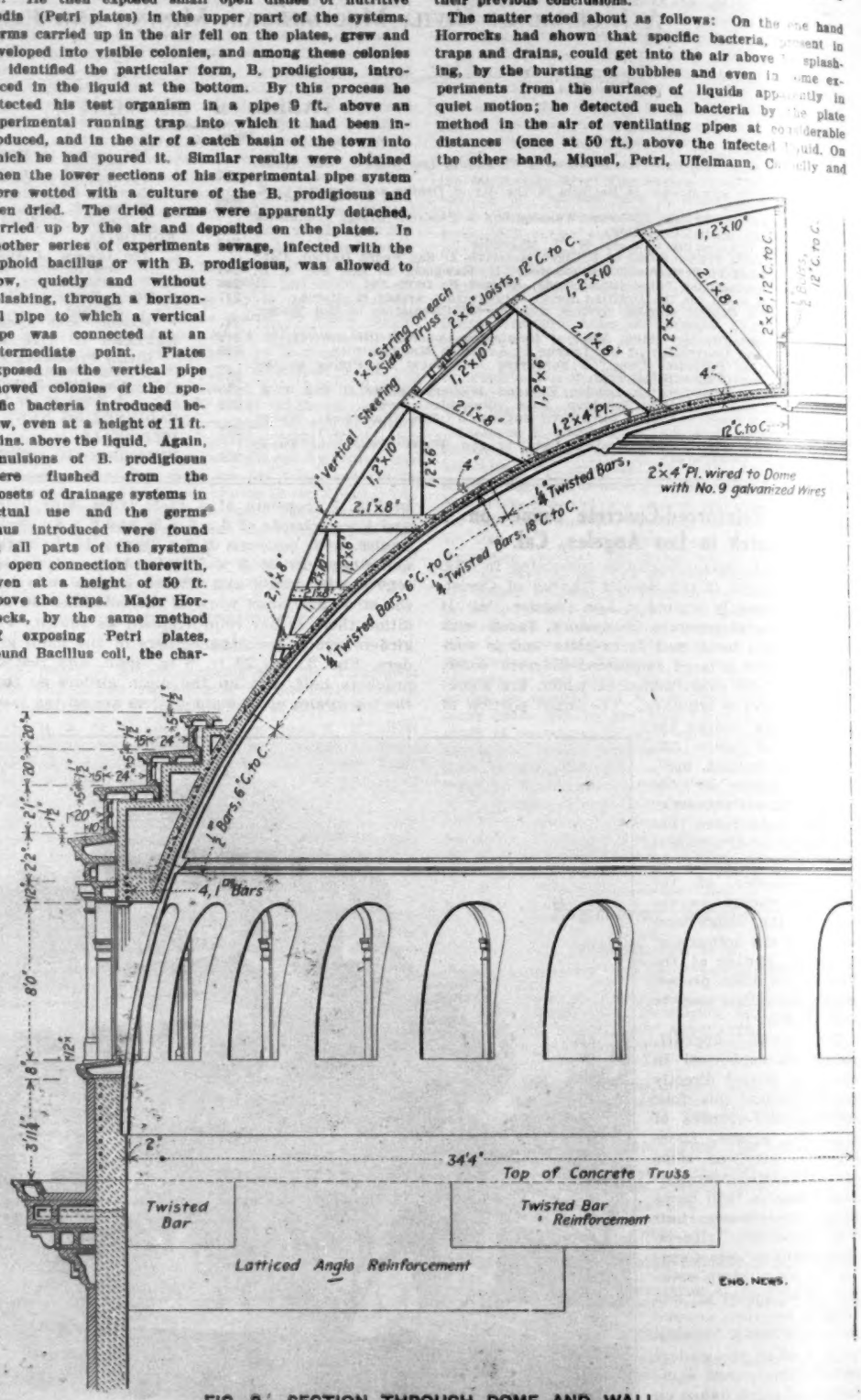

FIG. 2. SECTION THROUGH DOME AND WALL.

*Summary and Conclusions of a report made to the Sanitary Committee of the National Association of Master Plumbers of the United States, and reprinted from the Report of the Sanitary Committee for 1907-1908-1909.

†Biologist-in-charge of the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology, Boston, Mass.

[‡Although but recently published, this report is dated June, 1908.—Ed.]

*Dr. Andrewes' communications to which references are given at the end of this abstract have strikingly extended and confirmed Major Horrocks' work.

it was clear that they came from street dust infected by horse dung, etc., and not from the sewage at all. I then constructed an experimental pipe system, such as Horrocks used, consisting of a half-S trap of 6-in. tile drain to which an 8-ft. vertical stack of the same pipe was connected. A rich emulsion of B. prodigiosus culture, or of B. coli culture, in soapy water was poured through the trap and Petri dishes of nutrient gelatine or agar were suspended at various points in the pipe above. Control plates were also exposed at various points in the laboratory outside. Six out of 28 plates exposed in the pipe over the B. coli emulsion showed colonies of this germ, 14 colonies in all. Eight out of 24 plates exposed in the pipe over liquid infected with B. prodigiosus showed this organism, 17 colonies in all. The general effect of these experiments was therefore to confirm the results of Major Horrocks. My tests, like his, showed that specific bacteria are discharged into the air from the surface of foaming infected liquids and may be carried up in connecting pipes for considerable distances. Furthermore, I found that the velocity of an air current capable of transporting bacteria in the form in which they are sprayed into the air from an atomizer is very low indeed.

Granting, then, that infection of the air above sewage may take place, how can the results of actual examinations of sewer air be explained? The idea suggested itself at once that the whole question might be a quantitative one. It might be possible that under extreme conditions sewage bacteria get into the air but that the number discharged is so small under normal conditions that it does not appreciably affect the composition of the air of the sewer as a whole.

I next therefore attempted to investigate the question from this standpoint; and made first a careful examination of the best available quantitative methods. Horrocks' procedure of exposing open dishes of nutrient media to the air is of course not quantitative at all, since the bacteria which happen to fall on the plate are not related to any particular volume of air. The method adopted by most recent observers, and the one which I used in the experiments reported a year ago, involves the straining out of the bacteria in a measured volume of air by drawing it through a sand filter. The bacteria are then washed out from the sand in sterile water and enumerated by the ordinary cultivation methods. During my work this year I developed a new method in which a measured volume of air is drawn into two large culture bottles and the bacteria are allowed to settle out and form colonies on nutrient media in the bottom of the bottles. This method, although cumbrous, avoids all danger of losing bacteria by drawing them through the sand and was used in all my later work. A careful series of comparative tests showed, however, that the sand method used in other investigations is essentially accurate and earlier results may be accepted as correct in their general conclusions.

By the use of the Culture Bottle Method I next attempted to control Major Horrocks' results from the quantitative standpoint. I prepared a rich emulsion of B. prodigiosus, containing hundreds of millions of bacteria per liter, made it foam freely by beating it up with soap, and poured it into a large glass bottle or into an open dish. The air in the bottle, or the air of the laboratory over the open dish, was examined by the culture bottle method. Out of 50 liters of air examined, 5 only contained B. prodigiosus. In one liter, three were found, and in the other four liters, one each. Clearly the bacterial infection of the air produced by very vigorous foaming was but slight.

In these experiments there was but little splashing of the infected liquids; the bursting of bubbles from the foaming surface was the only source of air infection. I next imitated natural conditions more closely. Through the kindness of Mr. David Craig, of the Sanitary Committee of the Master Plumbers' Association, I had an ordinary porcelain water-closet bowl set directly on a 4-in. cast-iron S-trap, having a clean-out hole at its crown. The S-trap was connected at its lower end with an ordinary 4-in. running trap. A rich, soapy emulsion of B. prodigiosus was poured rapidly into the water-closet bowl so as to rush down through the two traps, foaming and splashing as it went. Samples of air were collected from the clean-out at the crown of the upper trap and from the upper opening of the lower running trap, a few inches only from the foaming surface of the liquid. Everything was as favorable as possible for the discharge of bacteria into the air. Yet, out of 44 liters of air examined, 43 contained no B. prodigiosus. One liter showed a group of eleven colonies apparently derived from a single infected droplet. It must be remembered that in these experiments, I used liquids artificially infected with large numbers of specific bacteria and caused to foam artificially by beating them up with a considerable addition of soap. Vigorous splashing was added to foaming in the last series of tests. Under these extreme conditions, as in Major Horrocks' experiments, the specific bacteria present could be detected in the air; yet the actual number present even here was extremely small.

These experiments seemed to offer a reasonable explanation of the difference between Major Horrocks' results and those of other observers. Bacterial infection of the air from foaming liquids may take place. Horrocks, using for the most part artificially prepared emulsions and ignoring the quantitative aspect of the case, naturally obtained positive results. When the question is approached numerically, however, the amount of air infection, even under extreme conditions, is so slight that one would scarcely expect the general air of sewers and house drains to be appreciably affected under normal conditions.

The final test of experimental conclusions of this sort must always be made by an appeal to existing conditions under normal circumstances of actual use. The numerous investigations cited above have shown that the air of street sewers is indeed singularly free from bacteria. The air of house drainage systems might, however, be supposed to be worse than that of the street sewers; and with regard to their bacterial condition only the single report of Uffelmann appears to be available. As a crucial test, I therefore determined to carry out a sufficient number of examinations of house drain air to gain a fair idea of its bacterial composition. With the cordial cooperation of Mr. Craig, I have been able to complete this work and to obtain results which seem to be conclusive.

I studied 19 different plumbing systems, 5 in buildings of the Massachusetts Institute of Technology, 4 in the wards of the Boston City Hospital, 3 in a block of East Boston tenements, 2 at the Boston City Hall, 2 at the Hotel Lenox and 1 each in the Ames Building, in the Technology Club, and in a private residence on Newbury St. The plumbing pipes were tapped at various representative points, on the main stack in the lower part of the building, on the projection of the main stack above the roof, on clean-outs on the main house drain, on wastes from fixtures and dead ends in connection with the house drain, and in one case on the ventilation system at some distance from the main stack. From each of 20 points selected, 10 liters of air were drawn off and examined for the characteristic bacteria of sewage, the colon bacillus and the sewage streptococcus.

In all, 200 liter samples of air were examined. Three samples were lost from the fact that the liquid sewage in the plumbing pipe ran into the collecting tube and over into the culture bottle, directly contaminating it with liquid. There remained then 197 tests. Of these 193 showed no sewage bacteria present. In the remaining four cases, sewage organisms were found, the colon bacillus three times and the streptococcus once. In each one of these four cases there was a discharge of sewage in the pipe at the point of examination, and at the moment the sample was taken so that spray was actually splashing in the air. In each of the four cases a sample of air from the same point ten minutes later showed no sewage forms present. In not a single case out of the 200 were sewage bacteria present in a liter of house drain air unless there was mechanical splashing at the point, and at the moment, of examination.

In general my results confirm the results of Horrocks in so far as they show that specific bacteria may be ejected from liquids into the air above. My tests of house drain air, like those of Carnelly and Haldane and Laws and Andrewes on sewer air, indicate that mechanical splashing may produce a local infection of the air in immediate contact with the spray. Such an infection does not, however, extend for any distance or persist for more than a minute or so. I found the general air of house drainage systems singularly free from bacterial life. Out of 200 liters examined, only 48 contained any organisms capable of development at 37°. Sewage bacteria were found in the air of the house drains only four times out of 200 liters, and then in the presence of mechanical spraying of sewage at the point of collection. The general air of the house drainage system, aside from this local infection, was, as far as examined, free from sewage organisms. These results accord well with those obtained by Miquel, Petri, Carnelly and Haldane and Laws and Andrewes in street sewers, and with those reported by Uffelmann for drain air.

The experiments of Major Horrocks, rightly interpreted, in no way contradict this general consensus of opinion. He demonstrated a possibility by using, for

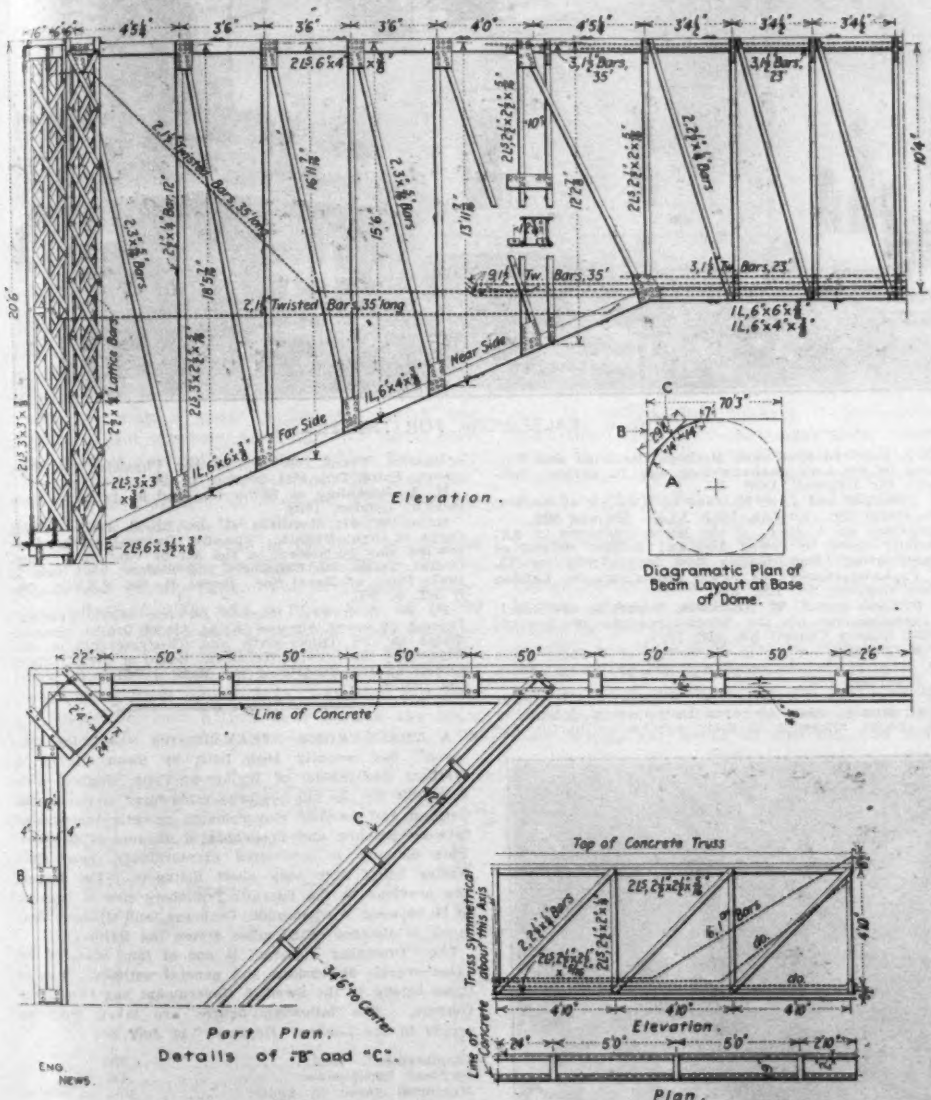

FIG. 3. DETAILS OF THE TRUSSES SUPPORTING THE DOME.

the most part, artificially infected, and foaming emulsions, and by ignoring all quantitative considerations. We must deal, however, in sanitation, not with theoretical possibilities, but with probabilities, measured as closely as possible in regard to their practical importance. I have found in my experiments that even under the most extreme conditions the number of bacteria which get into the air from an infected liquid is small. I have found by the examination of a series of plumbing systems in actual use that intestinal bacteria could only be isolated four times out of 200 liters, and then only at points of direct local infection from splashing.

In a surface water of good quality, like that of New York City, the colon bacillus can almost invariably be isolated from 10 cu. centimeters. This means a slight degree of intestinal pollution, but experience has shown that the chance of infection from such a water is but slight; and we drink it without serious alarm. If one were to breathe for 24 hours the undiluted air of a house drainage system, at any point not immediately infected by mechanical splashing, it appears that less than 50 intestinal bacteria would be taken in; for the daily consumption of air is about 10,000 liters, and in 200 liters I obtained negative results from air of this sort. In drinking New York water, twice as many colon bacilli are ingested every day, for 1,000 cu. c. is a small amount for daily consumption. So there would be less danger of contracting disease from continually breathing the air of a vent pipe, or of a soil pipe, except where liquid is actually splashing, than from drinking New York water.

There is a possibility of course that the gaseous emanations from decomposing organic matter may exert a pre-disposing influence which makes the body succumb more easily to specific germs, introduced in other ways. Many have held that in this way sewer gas might indirectly promote disease. This view, supported mainly by the experiments of Alessi, well deserves further study; but I have not dealt with it in the present investigation. I believe, however, that my results, in the light of all previous evidence, warrant the conclusion that the chance of direct bacterial infection through the air of drains and sewers is so slight as to be practically negligible.

[The body of Prof. Winslow's paper contains a number of references to the literature of his subject. The more important of these we have brought together and print below.—Ed.]

E. Frankland, On the Transport of Solid and Liquid Particles in Sewer Gases; Proc. Royal Soc., London, 1876-7, XXV., 542.

Raphael Pumpelly on The Relation of Soils to Health; Ann. Rep. Nat. Bd. of Health for 1881, p. 223. [Washington, D. C.]

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Uffelmann on Luftuntersuchungen, ausgeführt im hygienischen Institut der Universitat Rostock; Archiv fur Hygiene, 1888, VIII., 262.

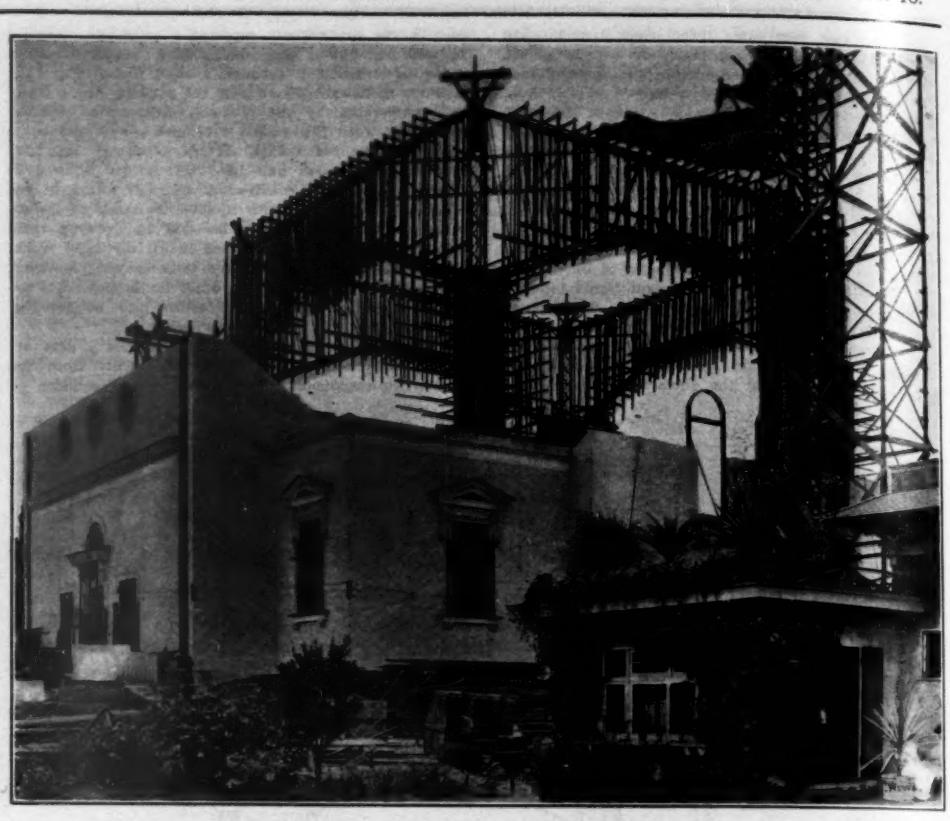

FIG. 4. FALSEWORK FOR TRUSSES.

R. J. Petri on Eine neue Methode Bacterien und Pilzsporen in der Luft nachzuweisen und zu zählen; Zeitschrift fur Hygiene, 1888, III., 1.

T. Carnelley and J. S. Haldane on The Air of Sewers; Proc. Royal Soc., London, 1887, XLII., 394 and 501.

Robertson on A Study of the Micro-organisms in Air, especially those in Sewer Air, and a New Method of Demonstrating Them; British Med. Jour., 1888, Dec. 15.

J. P. Laws, Report on Sewer Investigations; London County Council, No. 126, 1893.

J. P. Laws and F. W. Andrewes, Report on the Result of Investigations on the Micro-organisms of Sewage; London County Council No. 216, 1894.

J. McG. Smith on Air in the Sewers of Sydney; Sixth Ann. Rep. of the Metropolitan Board of Water Supply and Sewerage, 1893.

Dr. A. C. Abbott on Chemical, Physical and Bacteriological Studies upon Air over Decomposing Substances with special reference to their Application to the Air of Sewers; Trans. Congress of Am. Physicians and Surgeons, Third Triennial Session, p. 28.

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Major W. H. Horrocks of the Royal Army Medical Corps of Great Britain; "Specific" Bacteria derived from Sewage may be present in the Air of Ventilating Pipes, Drains, Inspection Chambers and Sewers; read Feb. 7, 1907; Proc. of Royal Soc., Series B, Vol. LXXIX., No. B 531, p. 235.

F. W. Andrewes, Reports on the Micro-Organisms Present in Sewer Air and in the Air of Drains. Supplements to the Thirty-sixth and Thirty-seventh Annual Reports of the Local Government Board of Great Britain, containing the Reports of the Medical Officer for 1906-7 and 1907-8.

FIG. 5. THE INTERIOR OF REINFORCED-CONCRETE CHURCH AT LOS ANGELES, SHOWING BEAMS AND GIRDERS SUPPORTING DOME AND CENTERING FOR DOME CONSTRUCTION.

A TRAIN-FERRY STEAMER, the "Drottning Victoria," has recently been built by Swan, Hunter & Wigham Richardson, of Walker-on-Tyne, England. This was built for the joint railway train-ferry service of the German and Swedish Governments recently inaugurated between Sassnitz and Trelleborg, a distance of 65 miles. This distance is considered extraordinary, most train ferries being over only short distances. The longest one previous to the Sassnitz-Trelleborg line is believed to be between Warnemunde, Germany, and Gjedser, Denmark, a distance of 26 miles across the Baltic.

The "Drottning Victoria" is one of four boats of the same overall dimensions and general outlines. Two of these belong to the Swedish Government and two to the German. The following figures are taken from an article in the London "Engineer" of July 30:

Displacement, tons	4,270
Nominal horse-power	440
Maximum speed in knots	16½ (on service)
Length, overall	370 ft.
Width, overall	53 ft., 6 ins.
Draft, loaded	16 ft., 6 ins.
Deadweight capacity	600 tons

Trains enter and leave the after end from a buffer slip and bridge built exactly to the form of the vessel. A standard train of eight cars can be carried on two parallel tracks, each 205 ft. long. Steadiness, during train shipping, is maintained by a system of trimming tanks in the extreme sides of the vessel. As the boat traverses water that is very rough at times, steadiness was considered of prime importance and the hull carries bilge keels to lessen rolling. The cars are held to their deck by screw couplings and the car springs are relieved by screw jacks under the bodies. In heavy weather the car roofs are fastened to the fore and aft girders of the over-deck structure.

Besides being equipped as a car ferry the boat is provided with the passenger accommodations of a first-class steamer—dining room, smoking, lounge and ladies' rooms, and regal apartments. All these are on the promenade deck. Below the car deck are accommodations for 96 first-class and 45 third-class passengers. The decorations and furnishings of the passenger accommodations are elaborate and beautiful.

The Monroe St. Bridge, Spokane, Washington; A Concrete Bridge Containing a 281-ft. Arch.

In a short time the city of Spokane, Wash., will begin construction of a bridge which will contain the longest concrete arch so far attempted and which in yardage will rank among the large concrete bridges of the world. As most of our readers will remember, the longest masonry arch in the world is that at Plauen, Germany, with a span of 295 ft. The next longest of masonry and the longest of concrete (Plauen arch is of stone masonry) is that now under construction across Rocky River, Cleveland, O., with a span of 280 ft., which the Spokane arch exceeds by 1 ft. We have been furnished a description of this latter bridge by its designer, Mr. J. C. Ralston, M. Am. Soc. C. E., City Engineer of Spokane, and from his notes have prepared the following article.

The site of the bridge is the line of Monroe St. where it crosses the Spokane River, at the lower end of the falls. The river has a low-water-flow of 2,000 and a flood flow of 40,000 sec.-ft. The 136-ft. falls are divided into a series of cataracts within a length of 1,300 ft. The down-town streets in both banks of the river are not more than 10 ft. above high water at the crest of the falls, but within four blocks the river drops into a gorge 140 ft. deep and from 1,200 to 1,500 ft. wide at its top. At present the crossing is made over a 17-year-old steel bridge consisting of a cantilever main span approached by truss spans and a trestle, a total length of 1,300 ft. This structure has proved too light, particularly in bracing and in details, for street-car traffic and has been condemned for two years for all but light vehicles and foot passengers.

The main spans of this bridge will be wrecked and in their place will be erected a concrete bridge and a retaining wall having a total length of 791 ft. The difference in length between the old and new bridge will be made up by an earth fill, made from the deck of the present steel bridge, ultimately burying the steel except the part to be wrecked. The fill, although containing over a million cubic yards, will be made without cost to the city, other than the wages of several dumpmen. The waste material from down-town excavations will be diverted to the fill and it is believed that three to four years will substantially complete that part of the work. This fill will reclaim land which now is useless and convert it into valuable down-town property, the aggregate value of which it is believed will approximate $1,000,000. The south end of the bridge is within four blocks of the banking center of the city.

At first it was intended to build the new bridge of equal length with the old and a number of designs were submitted for a concrete bridge of that size to cost $750,000. However, it was recently decided to build in the near future a 4-track steam railway with flanking electric car lines and streets crossing the line of the bridge at a high level, taking in space nearly 700 ft. north of the old south abutment. This new construction necessitated starting the new bridge far north of the old and also required that ample clearance be allowed for the railway tracks. As a consequence, a somewhat extraordinary layout and design were decided upon. Concerning this design Mr. Ralston says:

> It is perhaps not necessary to review in full the circumstances preceding the adoption of the present design. It will be noted with some amazement in many engineering quarters, that a design such as this, wherein there is no natural supporting ground for the south abutment, and in which it is necessary to build the abutment to a height of 140 ft., might be open to serious objections. If the profile of the site had a sharp bed-rock rise on the south, as it has on the north, from Piers 2 and 3, a more rational element justifying the design would be introduced. It is sufficient at this time to say that the early construction of a four-track main line steam railway, flanked by a number of electric railway tracks, beyond which still further to the south is a street, all passing, or to pass, under the deck of the present steel bridge, supplemented by a universal popular demand for a concrete instead of a steel structure, imposed upon the designer some rather heroic desiderata, as concrete bridges go.

The design adopted is, however, much cheaper than would have been one of the greater length first proposed. In addition, it will result in the creation of some very desirable real-estate, the value of which will accrue to the city.

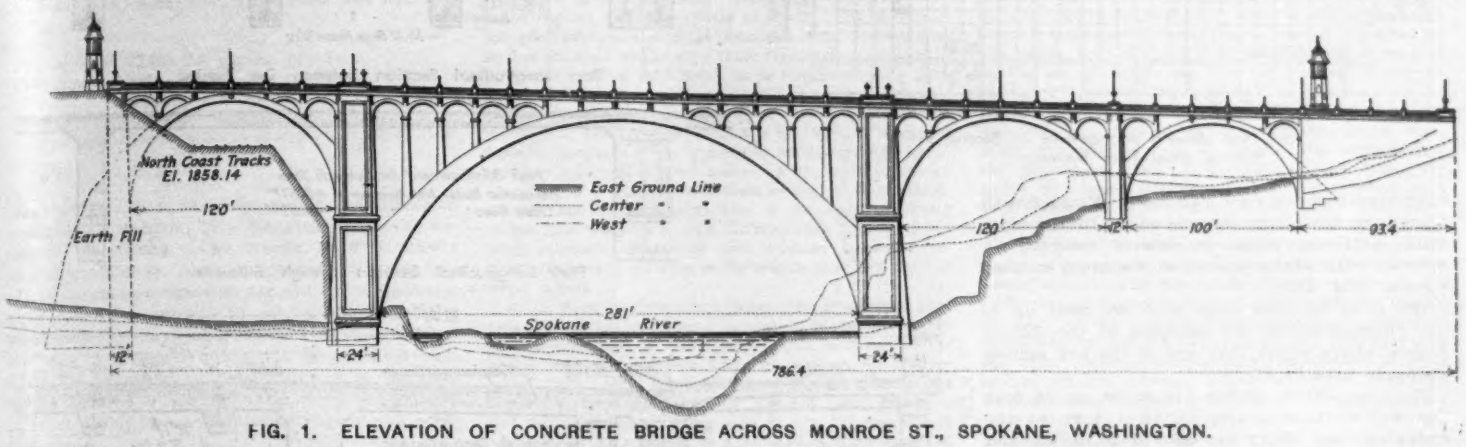


FIG. 1. ELEVATION OF CONCRETE BRIDGE ACROSS MONROE ST., SPOKANE, WASHINGTON.

The bridge is a concrete structure, 791 ft. long, with a 50-ft. roadway, carrying a double-track electric car line and a highway, and with two 9-ft. cantilevered sidewalks. It consists of a middle segmental span 281 ft. long, two 120-ft. semi-circular spans, one 100-ft. semi-circular span, a retaining wall 93 ft. long with a maximum height of 53 ft. The arches, with minor exceptions, are unreinforced, but the thinner members are all either of concrete reinforced with rods or wire mesh or of structural steel encased in concrete.

The main arch has an intrados on a 141.23-ft. radius, 281-ft. span and 115-ft. rise. It is of twin-rib construction, each rib being 6.75 ft. deep and 16 ft. wide at the crown and 18.5 ft. deep and 20 ft. wide at the spring, with a 36-ft. spacing between centers of ribs. Upon each of these ribs are solid spandrel walls, spanned by 20-ft. 5½-in. semi-circular arches up to the middle four panels, which are subdivided by smaller walls. These spandrel walls are spanned transversely all the way across the bridge by floor-beams made up of concrete encased I-

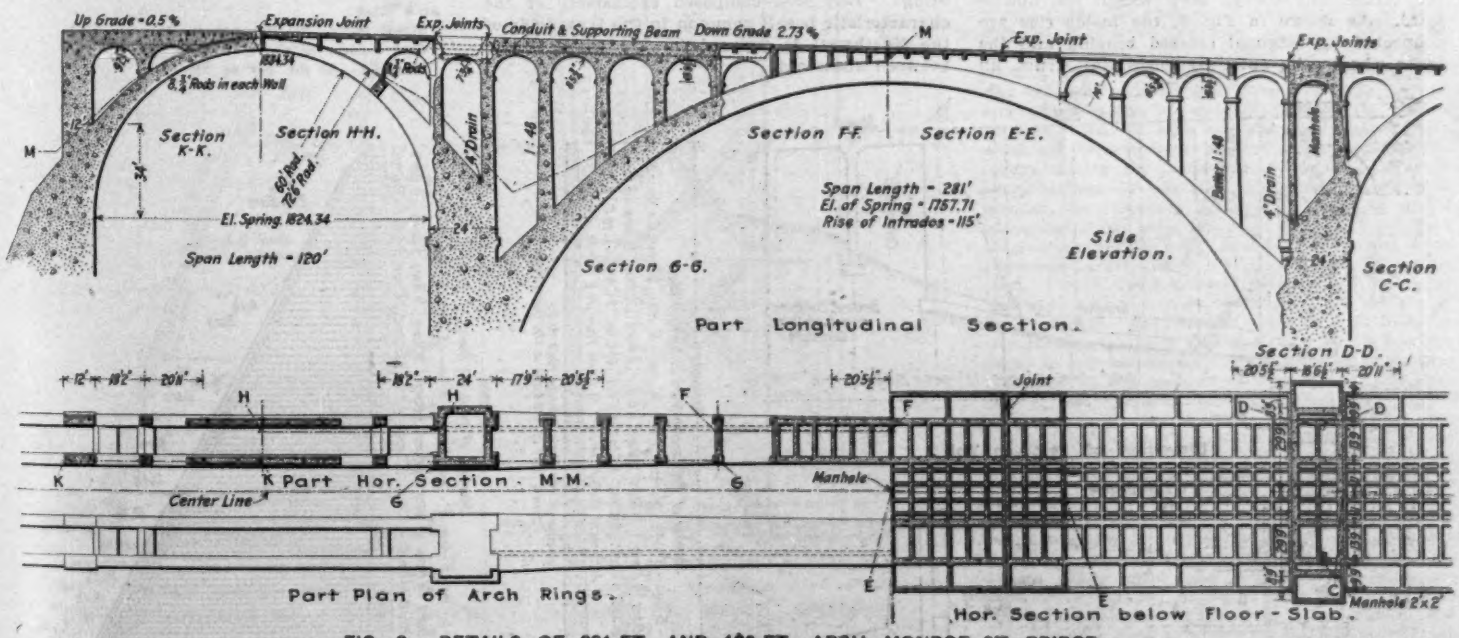
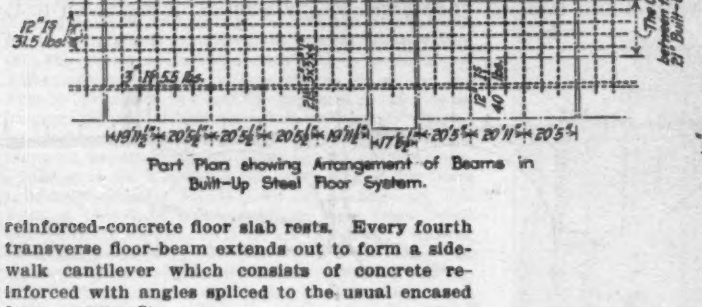
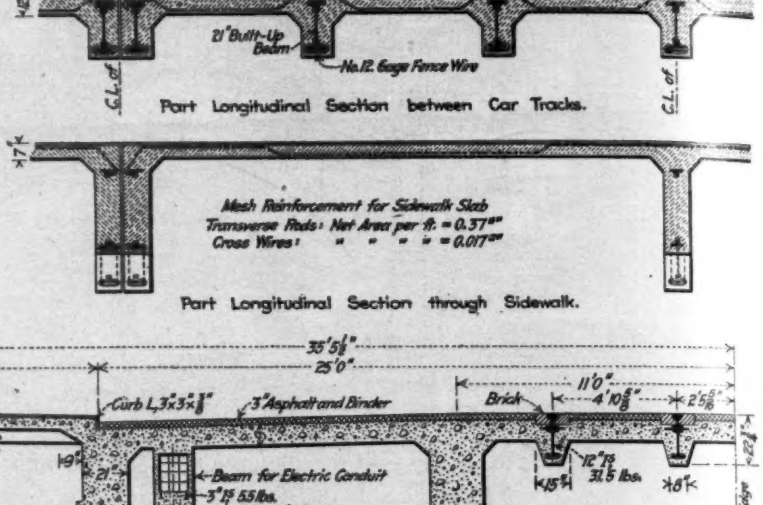


FIG. 2. DETAILS OF 281-FT. AND 120-FT. ARCH, MONROE ST. BRIDGE.

beams, 21-in. built-up beams across the middle two spandrels, for the street railway support, and 12-in. I-beams for the roadway. The floor-beams are longitudinally connected by similarly constituted stringers, making a regular rectangular floor-supporting system on which the reinforced-concrete floor slab rests. Every fourth transverse floor-beam extends out to form a sidewalk cantilever which consists of concrete reinforced with angles spliced to the usual encased I-beam (Fig. 3).


Exp. Joint
15"I, 42 lbs.
15"I,
Exp. Joint
3"I 5.5 lbs.
12"I 31.5 lbs.
The Cross-Beams between these Lines are 21" Built-Up Girders.
19'11½" 20'5½" 20'5½" 20'5½" 19'11½" 17'6½" 20'5½" 20'11½" 20'5½"

Part Plan showing Arrangement of Beams in Built-Up Steel Floor System.


Slab Reinforcement to Consist of Square or Triangular Mesh
Longitudinal Rods: Net Area per ft. of Width = 0.67 sq in
Gross Wires: " " " " " " = 0.017 sq in
Cantilever
Exp. Joint
21" Built-Up Beam
No. 12 Gage Fence Wire
C.L. of
Mesh Reinforcement for Sidewalk Slab
Transverse Rods: Net Area per ft. = 0.37 sq in
Cross Wires: " " " " = 0.017 sq in

Part Longitudinal Section between Car Tracks.

Part Longitudinal Section through Sidewalk.

The piers for this large arch are solid up to the intersection of the extrados of the 120-ft. arches, above which they are of the box section shown in plan in Fig. 2.

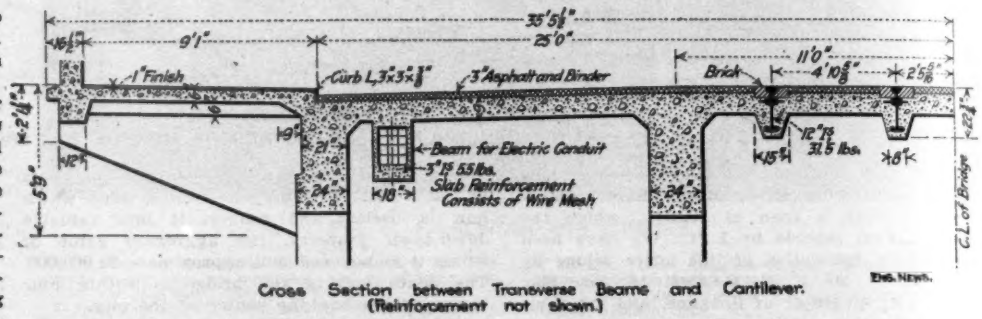
The two 120-ft. arches are made up of four ribs 4 × 4 ft. at crown and 8 × 4 ft. at the springing line. They are spaced 13.75, 22, and 13.75 ft. c. to c., respectively. The two outside ribs are connected with reinforced concrete struts and each rib has a slight amount of reinforcement at the quarter points of the extrados. The 100-ft. arch is similar to the 120-ft. arches, except that at the crown the dimensions are reduced to 3.5 × 4 ft. and at the spring to 7 × 4 ft., and is entirely of plain concrete.

The south abutment forms the most unusual feature of the design. On account of the peculiar conditions, noted above, it was necessary to make the springing line of the 120-ft. arch some 65 ft. above the rock foundation and to provide an abutment which would carry the sloped line of stress from that springing line to the rock. As designed, each of the four arch ribs is carried separately down to the base of the abutment, in such shape that the center line from the thrust will always keep within the middle third. As shown in Fig. 5, the inside ribs are connected by diagonal crossed bracing and the inner ribs to the outer by horizontal struts, all of concrete reinforced with rods. The abutment is thus hollow to allow the fill to tail through.

The north retaining wall is shown in Fig. 4. It consists of a high and thin reinforced-concrete face slab, counterforted on the inside with triangular-shaped buttresses which are anchored down into the solid rock by rods first set in the rock and extended up into the wall.

All the arches were analyzed on the elastic theory and the line of pressure for any loading is within the middle third, so that no reinforcing is needed in the main arch and only a slight amount in the smaller arches.

There will be no sub-aqueous work on the bridge. Bed rock composed exclusively of the characteristic basalt common to the lava fields of the Northwest is exposed for the whole length between abutments.



Cross Section between Transverse Beams and Cantilever. (Reinforcement not shown.)

FIG. 3. DETAILS OF FLOOR SYSTEM, MONROE ST. BRIDGE.

Following is an abstract of the specifications upon which the design was based:

LOADS.

MAIN.

Local Members.

Cars: 50-ton on each of the two tracks.

Highway:

Waddell's Class A for highways.

Floor slab: Standard 15-ton road roller given in Waddell's De Pontibus, using 750 lbs. per sq. in. in the concrete.

Also test the steel framing for the same roller, using a maximum fiber stress of 22,000 lbs. per sq. in.

Sidewalks:

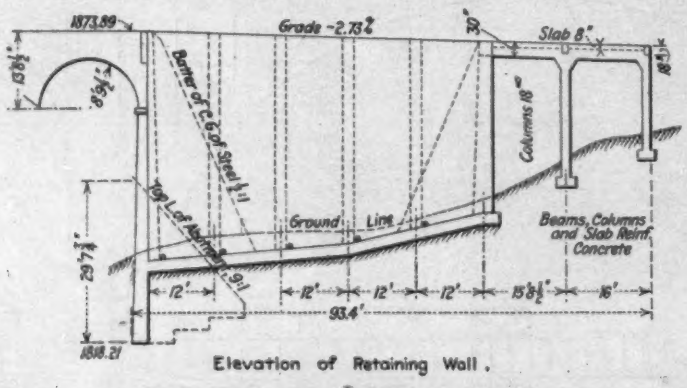
100 lbs. per sq. ft.

Arch Ring:

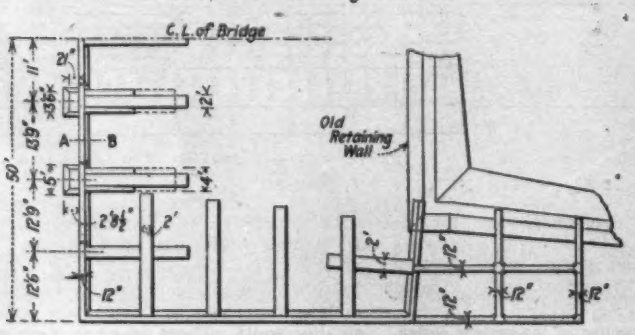
Street roads, 100 lbs. per sq. ft.

Cars: Same as above.

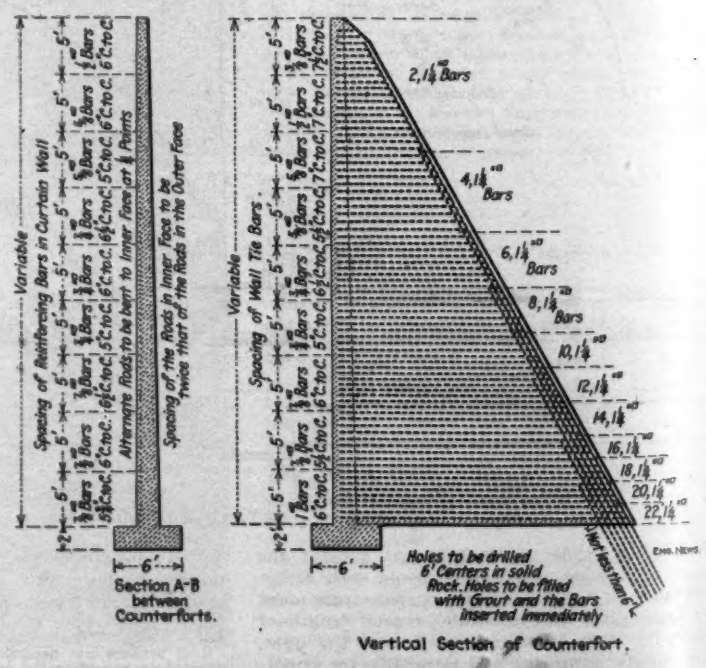
Sidewalk: 80 lbs. per sq. ft.



Elevation of Retaining Wall.



Half Plan of Retaining Wall.


Variable
Spacing of Reinforcing Bars in Curtain Wall
Alternate Rods to be bent to Inner Face at ¼ Points
Spacing of the Rods in Inner Face to be Twice that of the Rods in the Outer Face
Section A-B between Counterforts.
Spacing of Wall Tie Bars.
2,1¼ sq Bars
4,1¼ sq Bars
6,1¼ sq Bars
8,1¼ sq Bars
10,1¼ sq
12,1¼ sq
14,1¼ sq
16,1¼ sq
18,1¼ sq
20,1¼ sq
22,1¼ sq
Not less than 6'
Holes to be drilled 6' Centers in solid Rock. Holes to be filled with Grout and the Bars inserted immediately
Eng. News.

Vertical Section of Counterfort.

FIG. 4. DETAILS OF HIGH RETAINING WALL, MONROE ST. BRIDGE, SPOKANE.

IMPACT.
Local Members:
For highways—Waddell's highway impact.
For street cars—Average of Waddell's highway and railway.
For sidewalks—None.
For arch ring—None.
TEMPERATURE.
±20° F.
WIND.
20 lbs. per sq. ft. on exposed surface.

FIBER STRESSES.

ARCH RING.
Concrete. Maximum allowance, including live and dead load, wind and temperature, 600 lbs. per sq. in.
FLOOR.
Encased steel, 17,000 lbs. per sq. in.
Floor slab concrete, 500 lbs. per sq. in.
(Except as noted above.)
In reinforced concrete,
p = proportion of steel to concrete = 0.7% in slab.
$$n = \frac{E_s}{E_c} = 15.$$

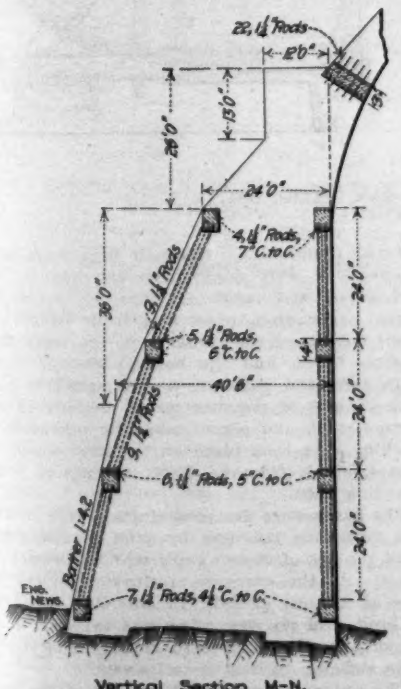
The bridge was designed under the direction of Mr. J. C. Ralston, City Engineer, with the assistance of Messrs. J. F. Greene, P. F. Kennedy and Roy Maloney, Ass't Engineers. All but one of the concrete bridges so far put up in Spokane, have not been let out to contractors but have been built by day labor under the direction of the City Engineer's office. It is probable that the same procedure will be followed in the case of the Monroe St. bridge, and work is expected to start under these conditions during the present month.

Five-Year Engineering Courses.*

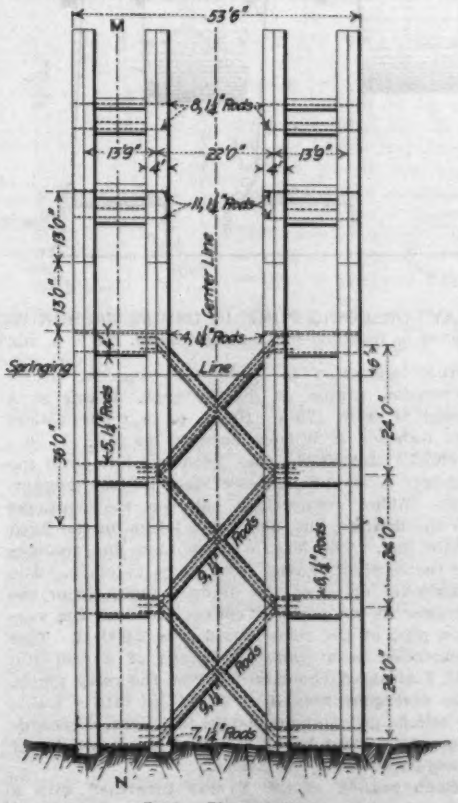
By W. T. MAGRUDER.†

After a joint session of the Society for the Promotion of Engineering Education and the American Institute of Electrical Engineers in 1903, the writer had the temerity to suggest that it might be well to extend engineering courses to five years. The writer was told, "Young man, if you want to lose your job, just suggest a five-year course at your university." Such advice may have been good then but now it would hardly be taken seriously by one acquainted with American college conditions.

The term "five-year courses" can properly be applied to any curriculum, or course of study, which is scheduled



Vertical Section M-N.



End Elevation.

FIG. 5. DETAILS OF SOUTH ABUTMENT, MONROE ST. BRIDGE, SPOKANE.

to require five years for completion. Of such, at least four are known.

(1) The oldest is a four-year undergraduate course followed by a year of post-graduate study. In many cases, the year of post-graduate study was spread over two years so as to permit the student to earn an income as a teaching-fellow or assistant. The work done in the fifth year was usually strictly professional, rather than either cultural or broadening in its character. The degree given was either the master's degree or a professional degree. Statistics will show that less than 3% of the students in the different institutions who finished the four-year curriculum returned to take the fifth year.

(2) In many of the engineering colleges there are many young men who, having worked at some vocation and having accumulated a few hundred dollars, are extremely ambitious to get a technical education. Not infrequently, their savings are expended before the course is finished and they either drop out for a year or two, or get a position which will permit them to continue their studies for part of the time. It has been suggested that, if the regular four-year course of study could be spread out over five years and the schedule could be arranged so that students would have their class-room and laboratory work come at such hours as to economize their time and permit them to devote a half-day at a time to money-earning occupations, more students would complete the course and fewer would drop out for lack of adequate financial means. When a mature, ambitious, and hard-working American student makes up his mind to get an education, it is the part of wisdom as well as of kindness, to help him on and assist him in his good endeavors rather than hinder him with technicalities. Many of our most successful practicing and teaching engineers received their early training in the schools of self-denial and small means.

(3) In many engineering colleges, the established pace proves to be too swift for a number of students who are usually accounted as being slow. This may not be the proper time and place to make an apology for the so-called "slow" man, but it should be remembered that the world has been using him for a great many centuries and will probably continue to do so. In the engineering world, every man cannot be a foreman, a superintendent, or a head professor. What the slow man learns, he usually retains admirably, and, as a result, he can be depended upon. If, therefore, the regular four-year curriculum and the schedule of classes and laboratory exercises could be spread out over five years for him, in a way similar to that best suited for the student who has to earn his income as he spends it, then more students would be graduated and the world would be better off by having a larger number of well-trained, steady-going and reliable men on whom to draw. If a student is only slow, and neither lazy nor stupid, he will, as a rule, well repay the thought, guidance, and efforts of his professors and advisers.

(4) For many years it has been felt that the present curricula of our engineering colleges were too specialized, that they needed to be broadened, and that we were training a fairly efficient engineering machine, but one not adapted to a variety of conditions. Efforts to broaden the curricula and to inject more culture into it have been met by indifference, even by opposition, from the conservative professors of the academic college. So far as known, Harvard University is the only institution which requires a bachelor's degree from an acceptable institution as a requirement for admission to its regular course of engineering study. At most colleges and universities, it is thought that seven years of a man's life is too much to give to his collegiate training in engineering. Hence courses of study, covering the regular course leading to the degree of bachelor of arts, supplemented by one of the regular engineering courses and requiring from five to six years for completion, are now being offered in a dozen or more of our universities.

The writer was appointed chairman of a committee of the faculty of the Ohio State University, charged with investigating combined courses of study leading to two degrees. It is thought that some of the information obtained possibly may be worthy of record. Opinions on this subject were obtained from the presidents of some 21 institutions, either in the form of personal replies in answer to a set of eight questions, or of reports on the subject made to their faculties or to their boards of trustees. Also personal replies to the same list of questions were received from 28 deans. The statements in the catalogs of about 25 institutions were taken, together with papers dealing with this subject which have been presented to education associations. This large collection of evidence and opinion was codified and the excerpts made therefrom formed a report of some 150 pages of typewritten matter. From this report the following miscellaneous conclusions properly can be drawn.

There is an increasing demand for an education broader than that of the usual so-called professional curriculum in engineering, and yet more specific than that offered by the usual academic curriculum. This demand is being met by students following either a combined curriculum leading to two degrees or following two curricula, one after the other. Such combined curricula leading to two degrees are of increasing popularity where publicly offered and scheduled or when openly advocated and urged by the leading members of the engineering faculty. The longest time required for combined courses of study is at Harvard, where it is seven years for arts and engineering. Another institution confers a bachelor's degree at the end of the third year and a master's degree at the end of the fourth year. This is the only case found of two degrees being given for a four-year course of study and was not in engineering.

It has been found that if the first three years under the combined curricula are taken in the academic college, the work of the engineering college can be completed in three additional years, or in a total of five years if work is done in the summer terms. Arrangements have been made, between different institutions in the same state, whereby work at one will count towards a degree from the other. To complete the work required for the two degrees in six years, or in five years plus summer terms, concessions usually must be made by one or the other of the faculties granting the degrees, and usually by the faculty of arts and sciences, as it is recognized that the professional work cannot be as easily curtailed in amount and must be more definite and specific. Combined curricula could be more frequently taken if the students had fixed their desires and could map out their curricula beforehand and if the professors in mathematics, languages, drawing, and the sciences knew in detail the kind and character of instruction which was desired for the student by the faculty of the college offering the professional curriculum. Students migrating from one institution to another, with advanced standing, are frequently handicapped in getting credits which they might have obtained if their work had been chosen more carefully and to meet the requirements of the professional curriculums. The faculties of the institutions, whence these students come, would be better pleased if migration could be deferred until the end of the third year. The students would be more likely to stay through the third year if it were known that the degree in arts and science would be awarded by the first institution on the satisfactory completion of the first year of the professional curriculum elsewhere. An increase in the number of undergraduates in engineering who had been trained in the arts and science courses, would improve the average attendance of the upper classes in the professional courses, would tend to raise the standards of scholarship, and would establish a precedent, for the student, of taking more cultural work before beginning the professional course of study. As a result the various colleges would come into closer relations. They would better understand and appreciate each others' aims and standards, and a more kindly feeling would be engendered among the undergraduates. The existence of a body of alumni having degrees from two institutions would tend to keep down animosity and jealousies, ill-will and bad feeling.

It is quite possible that certain of our engineering colleges may not be able to get the sympathetic cooperation of the colleges of arts in their desire to inject more culture into the present engineering curriculums. In this case, it may be necessary for the college of engineering to offer the culture subjects as part of the regular undergraduate course in engineering which will then have to be of five years' duration.

*From a paper presented at the meeting of the Society for the Promotion of Engineering Education, New York City, June 24.

†Professor of Mechanical Engineering, Ohio State University, Columbus, Ohio.

The Hydraulic Transmission of Dredged Materials at San Pedro Harbor, Cal.; A Record of Performance.

By H. HAWGOOD,* M. Am. Soc. C. E.

In the work of filling and reclaiming submerged lands at San Pedro, Cal., the Pacific Wharf & Storage Co., from the summer of 1907, to May, 1909, repumped to distances varying from 235 to 3,736 ft. the discharge of the United States suction dredge engaged, under the direction of the U. S. Engineer Corps, in deepening the inner harbor at San Pedro. The installation and operation of the wharf company's plant were under the direction of the writer.

An understanding of the general arrangement will be conveyed by briefly describing it as a pipe line extending a mile or more from the floating dredge, with the relay pump inserted in the pipe line at a point on the dredger side of the midway point.

The plant being electrically driven, the meters on the switchboard afforded a ready means of ascertaining at any moment the consumption of power. These meters, and the pressure and vacuum gages on the discharge and suction pipes, were read and recorded hourly, together with the length of pipe through which the dredgings were being discharged. The plant ran continuously, day and night, except from midnight Saturday to midnight Sunday, and for such stoppages as were needed for repairs of the plant, or for dredger movements and repairs.

From commencement to finish of the work for which it was installed, the plant was in actual working operation somewhat over 6,966 hours. The data which are here given, necessarily in condensed form, are the result of more than 7,000 simultaneous records of power, working heads and pipe lengths. The quantity of solids transported was obtained monthly from the measurements, in place, of the U. S. Engineers, averaged for the number of hours worked during the month. A closer method of apportioning the solids was not feasible, nor would it apparently have been of any material value, for it is to be inferred from the records that, so far as the solids are concerned and within the ranges of their percentage occurrence, it is frictional qualities rather than actual quantities that most affect the consumption of power. The total quantity transported was 975,213 cu. yds., the general average per hour, 140 cu. yds. The percentage of solids ranged from 3.5% to 5.2%, with an average of 4.8% of the gross volume of water and solids. The total volume was determined by area of pipe and velocity of flow, as ascertained by introduction of permanganate of potash into the pump, and timing appearance of the colored water at pipe end. The coloring was readily discernible except when the discharge was exceptionally black. The average velocity of discharge flow was found to be 10 ft. per sec. The solids consisted of soft rock, clay-coarse sand, shells, quick sand and some mud.

The cost for operation and repairs, with current at 1⅛ cts. per KW. hour, was 4.89 cts. per cu. yd., exclusive of depreciation of plant. The average movement to which this cost applies is 2,223 ft.

Notwithstanding the growing importance in certain classes of engineering work, of hydraulic methods of transmission of earth materials, the literature of the subject is very quiet on the subject of power consumption, a defect that may be attributed in part, at least, to the heretofore general use of steam power, and the cost incident to taking and computing indicator cards at close intervals, a labor which would require a special staff for its performance. In the present instance advantage was taken of the opportunity offered by electrical meters for speedy determination of power to gather a continuous record of the performance of the plant, both for guidance in its economical operation and for use in further installations.

The pumping machinery of the U. S. dredge "San Pedro" consists of a 20-in. centrifugal pump with shell 8 ft. in diameter, and 6-ft. runner, direct connected to a 600-HP. vertical triple-expansion engine of marine type, driven at a speed of from 175 to 200 r. p. m. The boilers are Babcock & Wilcox, burning oil fuel.

INSTALLATION.—The discharge line from the dredger is of ⅛-in. riveted steel, 20-in. diameter, with rubber connections between the pontoons on the floating line, and drive-joints on the fixed shore line. The length of pontoon line changes as the dredger moves from place to place. The maximum drive of the dredger pump from the dredger to the point of connection with the suction pipe of the relay pump was 2,600 ft. This connection was made by means of a cast-iron 45° Y situated about 80 ft. from the relay pump. The divergent branch of the Y led into a waste or relief line of about 300 ft. in length, discharging onto the sea beach remote from possibility of interference with the harbor.

Each branch of the Y was furnished with a gate, the one on the waste line being so actuated and governed that it automatically opened if the speed of the pump from any cause fell 25% below the normal. As first installed, the main and waste gates were inter-connected, so that as the one closed the other opened. This was found in practice to be an unnecessary complication and was discontinued. The main gate was afterwards always kept open unless the pump was to be out of service for some length of time, when it was hand closed as a measure of precaution against the pump itself being "plugged." Ordinarily the rise of 4.6 ft. existing between the Y and pump sufficed to prevent discharge into the pump shell as long as the waste gate was open.

Automatic appliances for the opening of a relief or waste line are quite essential to the successful operation of installations such as this where primary and secondary pumps are operated entirely independently, and out of sight of one another, and particularly where, as in this instance, the secondary or relay pump is operated by a commercial power current liable to shut off at any moment without warning, and to stay off for a greater or less period of time.

The gates were simple and of moderate cost, costing $133 each. The raising and lowering movements were by an internal rack and pinion, the pinion spindle working through a stuffing box and carrying a sprocket wheel on the outer end. The gate seats, which are conveniently removable for replacement when worn, had a life of about three months. If a reliable supply of water under pressure had been available, it would have been economical to have used seats perforated with small holes for the discharge of wash water over their faces. Such seats were tried at first, but the water supply, being dependent upon the relay plant being in operation, was subject to interruption at each shut-down of electrical current, when the perforations would become choked, and the cost of re-opening destroyed their value. One-half inch wash water connections were made with the bonnets over the gates, and these openings, on account of their larger size, were free from trouble. If from any cause the pressure in the wash water system failed, and the bonnets became packed with sand and shells, it was a matter of but a few minutes of resumed water pressure to clear bonnet, rack and pinion ready for operation. No packing ever took place on the gate which was closed, but it did take place at times on a gate standing open.

The gates were designed single seated to avoid the inevitable jamming by sand that would attend the use of wedge gates with seats back and front. As the gates were situated on the pipe line at a point of light vacuum, the single seat sufficed, and no chattering was experienced, the velocity head of the stream impinging on the gate sufficing to hold it to its seat.

The automatic and quick raising of the waste gate was accomplished through a sprocket wheel and flat link chain drive, actuated by the fall of a box loaded with sand. The box was raised by a hand winch and there held by a latch until tripped by the slowing down of the centrifugal governor.

STEEL VS. WOOD PIPE.—The pipe line between the dredger and the relay pump was of steel, as previously mentioned. The discharge pipe from the relay pump to the lands being filled was of Douglas fir, manufactured at Olym-

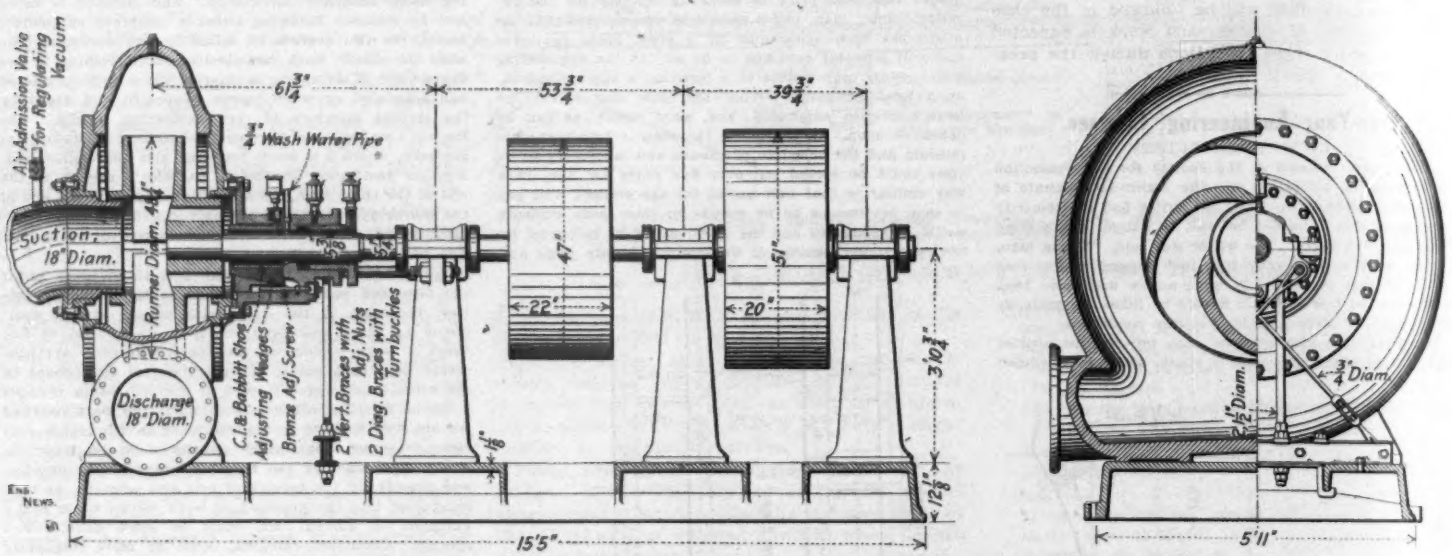


FIG. 1. DETAILS OF "RELAY" DREDGING PUMP IN USE IN HARBOR WORK; SAN PEDRO, CAL.
(Belted to Induction-Motor Pump. Speed, 398 r. p. m.)

*Consulting Engineer, H. W. Hellman Building, Los Angeles, California.

pia, Puget Sound, by the National Wood Pipe Co. This pipe was 20-in. internal diameter, made in from 8 to 16-ft. sections, built up with from 13 to 20 staves, each of the full length of the section, and bound together by a spirally machine wound No. 0 galvanized steel wire. The staves, when new, had a finished thickness of 1⅞-in. The sections were joined together in the line by wood collars 8-in. long, made of staves of that length bound together by three ½-in. bands with shoes and nuts.

The use of the metal and wood pipe on the same service, and subject to identically the same wear and tear, permitted an interesting and profitable comparison of their working values.

The average life of steel pipe was six months, the average life of the wood pipe 13 months. The periods include in each case all prolongation of useful life made possible by repairs, the possible repairs to steel pipe being limited to replacement of rivets whose heads may have been cut away, and to the renewal of abrasions of the asphalt coating. Where the upper portion of the pipe was not corroded too badly, a turn of 180° could be made, bringing the bottom portion,

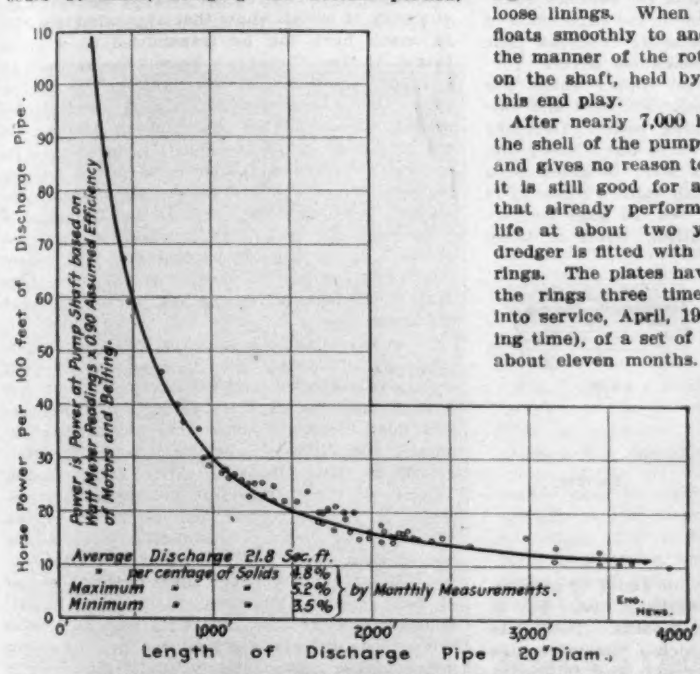

Horse Power per 100 feet of Discharge Pipe.
Power is Power at Pump Shaft based on Watt Meter Readings x 0.90 Assumed Efficiency of Motors and Belting.
Average Discharge 21.8 Sec.ft.
per centage of Solids
Maximum " " 5.2 %
Minimum " " 3.5 %
by Monthly Measurements.
Eng. News.
Length of Discharge Pipe 20"Diam.

FIG. 2. PERFORMANCE OF 18-IN. CENTRIFUGAL PUMP IN REPUMPING DREDGINGS, SAN PEDRO, CAL.

(Relation between length of discharge pipe and power required.)

Runner, 48¼ ins. diam. Speed, 398 r.p.m.
Running time, 6,966 hours, 1907-08-09.
Solids pumped, 975,213 cu. yds. Av., 140 cu. yds. per hr.
Electric power, 2,000-volt induction motor.

which had been subjected to the most wear, into a position of little wear, where it was good for some further service.

In the wooden pipe, the wear was confined almost entirely to the staves occupying the lower one-third of the circumference, and the pipe could be turned twice, with a movement of 120° each time. Staves could be and were replaced by rolling the pipe sections out of the line and leaving them to dry and shrink in the sun until loose enough to admit of driving out the worn staves from under the spiral winding and driving in new. The subsequent soaking when put back into service made all tight again. Some of the replacement staves were of entirely new material, others were taken from sections of pipe that were scrap except for a few of their staves still good for more service. The relative expenditures for equal lengths of steel and wood pipe, including first cost and all repairs during their lifetime, were, steel 100, wood 54. The evolution of the inexpensive sun shrinking method of stave changing contributed largely to the economy of the wood pipe.

RELAY PUMP.—The 18-in. centrifugal pump (Fig. 1) of the relay plant has a shell 87 ins. in diameter, and runner 48¼ ins. in diameter, with average speed of 398 r. p. m. Except for fluctuations due to the fluctuations of voltage, common to commercial power lines, or some such fortuitous cause as obstruction in the runner ports, the speed was very steady. The character of some of the things that passed through the runner and were discharged through the pipe line is remarkable; for example 30 ft. of 1¼-in. wire cable, a 3-ft. length of 3-in. pipe, with the remains of a brass valve at one end, and a T at the other were among the curiosities. Substances of a specific gravity near to or somewhat less than water, were readily held by the force of the inflowing water against the end of the shaft and face of runner, in which position they obstructed the ports and disturbed balance, and caused more trouble than heavier things.

The use of an 18-in. pump on a 20-in. pipe line was a matter of market conditions, not of mechanical design, but apparently it accomplished the work as effectively as the 20-in. pump on the dredger.

The pump was manufactured by the United Iron Works, Oakland, Cal., from the designs of that company. Prominent features of the design are the absence of thrust bearings and loose linings. When at speed, the runner shaft floats smoothly to and fro in its bearings after the manner of the rotor of a generator. Collars on the shaft, held by set screws, serve to limit this end play.

After nearly 7,000 hours actual working time, the shell of the pump shows but moderate wear, and gives no reason to think otherwise than that it is still good for a term of service equal to that already performed. This places the shell life at about two years. The pump on the dredger is fitted with changeable liner plates and rings. The plates have been renewed twice, and the rings three times since the dredger went into service, April, 1906, the average life (working time), of a set of liner plates and rings being about eleven months. The indications are good that the shell without liners will prove the more economical to maintain, besides eliminating the danger, which is by no means fanciful, of a liner getting adrift and doing damage before the machinery can be stopped.

As a safeguard against unforeseen wear on the shell, leading to a sudden breakdown, holes were drilled into it from the outside at crucial points, each to a depth of 1 in., so that when the remaining metal became worn out, and the drill holes began to spout a warning, there would still be an inch of metal left in the shell.

The runner weighs approximately 3,000 lbs. The first two had an average life of about 2,000 hours each; the third runner, in which the metal was thickened at places of greatest wear, was still in service at completion of the work after 2,941 hours' service, although just about worn out.

The gland bearing of the pump as first installed was not adjustable. Many and varied troubles arose from lack of means to take up wear, aggravated by the overhang of the heavy runner. The babbitted bronze shoe wore out rapidly at the inner end of the bearing, permitting the shaft end to droop, with resultant hot bearings, cutting of shaft and heavy vibration of pump, all tending to make it difficult to run week in and week out without stoppage and adding materially to cost of maintenance.

The adjustable bearing shown in the drawing was then designed under the writer's direction, and substituted. The improvement was very noticeable, heating and vibrations disappeared, the pump ran very smoothly, and the extra cost of $250 was justified.

The pump shaft, provided with two pulleys, was originally belt driven by two induction motors of nominally 200 and 100 HP., taking three-phase current at 2,000 volts. Before the work was completed, outside conditions arose that necessitated the removal of the plant to a more remote location, requiring the addition of a third motor of 200 HP. This was done by belting it and the smallest motor to the same pulley, the belt of the smaller motor running inside that of the larger. The proper distribution of work between the three motors was accomplished, as far as practicable, by proportioning the diameters of the various pulleys, the final adjustment being made by disconnecting and insulating from the rings one end of one or more conductor bars of the rotor whose speed was too high. By these methods the work was so distributed that each motor did its fair share of the work, and none overheated.

The elasticity of a belt-driven plant is well illustrated by this instance of ability to meet emergency conditions. Belts have another good feature in that they will slip when the pump runner is brought up all standing by a rock or other foreign substance, and the strain of bring-

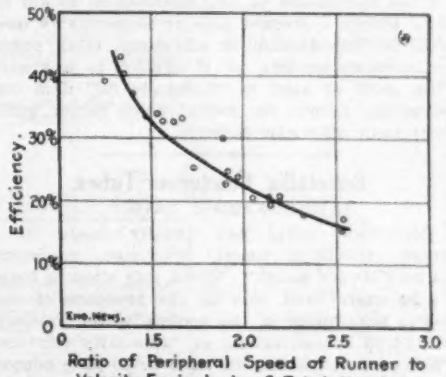


Fig. 3. Performance of 18-in. Centrifugal Pump in Repumping Dredgings, San Pedro, Cal.

(Relation between peripheral speed ratio to velocity equivalent of total head and efficiency.)

ing to rest the heavy and fast rotating parts of the motors is very sensibly softened.

On the bed plate of the pump, and belt-driven from the main shaft, was placed a small centrifugal governor operating a trip. This was so arranged and adjusted that on the speed of the pump falling 25% below its normal, the tripping device came into action, releasing the trigger of the gear to open the gate of the waste pipe line, and opening an oil switch in the main power circuit between the motor switchboards and the transformers, making it impossible for the motors to get current with the pump slowed down or stopped, even though the circuits were closed and in the operating position. Upon the oil switch being opened it became mechanically interlocked against being reclosed until the motor switches were first opened. The motors were protected against overload by the usual fusing devices.

PERFORMANCE OF THE PUMP.—The total power consumed per 100 ft. of pipe for the different lengths of discharge, is shown in the accompanying diagram (Fig. 2-3). Until observations numerous enough to cover a sufficiently wide range had been obtained, the cause of this paradoxical effect, which also appeared in other plants, was obscure. As the work progressed, however, and more and more records became available for examination, the chief cause became prominently defined as the relation existing between the peripheral speed of the pump runner and the velocity equivalent to the total gage head against which the pump operated. This is graphically shown on the same diagram. The most economical peripheral speed for the particular runner in question is indicated as being about 125 to 130% of the equivalent velocity of the total opposing head as shown by the pressure and vacuum gages.

Where the work embraces great changes in pipe lengths or vertical lift, variation of speed should be made to accomplish a minimum con-

sumption of power. With constant speed motors, this could be obtained in reasonable steps by the use on the motor shafts of changeable pulleys of different diameters, the motor beds being sufficiently long to admit of movement necessary to fixed belt length. An installation of variable speed motors would be costly and lacking in simplicity.

The use of jets of high pressure water, suitably introduced at intervals along the length of a discharge pipe, for the purpose of relieving the main pump on long drives is a field worthy of exploitation. It was the writer's intention to have done this had the exigencies of the San Pedro work ultimately called for more power than the pump shaft could safely carry. The mechanical efficiency of such jets might not be high, but there would be compensation in reduction of cost of both installation and operation. The "Greathead" injector fire hydrant of twenty to thirty years ago, utilizing a small, high pressure jet to accelerate the main stream, was successfully used in one or two towns in England, and some measure of success is to be anticipated in the application of like methods so to aid the flow within a dredger pipe as to profitably obviate the introduction of additional relay pumps on a pumping line, or if applied to a gravity line, such as used in "hydraulic fill" dam construction, permit the use of much flatter gradients than otherwise possible.

Bimetallic Condenser Tubes.

By EDWARD K. DAVIS.*

Condenser tubes are usually made of a brass containing about 40% zinc, commonly called "Muntz metal." When this alloy is found to be short lived, due to the presence of corrosive substances in the cooling water, recourse is had to bronze tubing of "admiralty mixture" (87% copper, 8% tin, 5% zinc) or to pure copper. Sometimes also the tubes for further protection are tinned on the inside or on both sides. However, neither brass tubes nor the more costly substitutes of bronze or copper are entirely satisfactory under ordinary conditions and under extraordinary circumstances their lack of durability is a source of annoyance and expense.

A condenser tube to be of value should not split, should be comparatively free from localized corrosion or pit holes, and should not become brittle under the combined action of steam and cooling water. Failure of a tube is generally due to one or more of these causes.

A bimetallic tube, composed of a copper envelope over an aluminum lining (or vice versa) is unlikely to split, owing to its being composed of two layers of metal. It is slow to corrode with the aluminum surface exposed to the cooling water, and there is no tendency shown toward becoming brittle. (In the majority of cases the cooling water is carried through the tubes and the steam to be condensed impinges on the outside of the tubes. In some instances, however, the order is reversed, the steam being inside and the water on the outside. For such cases the order of copper and aluminum can be reversed.) A tube combining these qualities is therefore more durable than any other that has yet been tried in surface condensers.

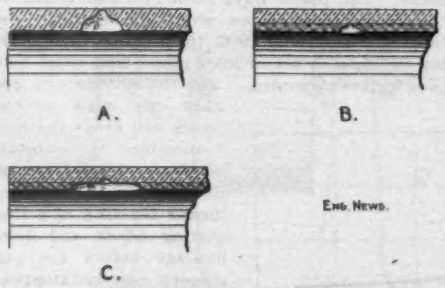
The laminated or bimetallic wall of such a tube is obtained by drawing a seamless copper tube over a similar but smaller one of aluminum. The copper envelope is drawn over the aluminum tube by means of a draw-bench of the ordinary type. The aluminum shell and the copper shell are first drawn separately to approximately their respective diameters and thicknesses; then the copper tube is slipped over the aluminum and both are put through a finishing die which forces the copper very tightly over the inner shell. The usual proportions of metal are, 0.022-in. wall thickness of copper and 0.043-in. wall thickness of aluminum, making a total wall thickness of 0.065-in., or No. 16 Stubs gage. To secure a thickness of No. 18 Stubs gage (0.049-in.), the thickness of aluminum is reduced to 0.027-in., leaving the copper the same as before. It has not been found feasible to make the wall thickness of such bimetallic tubes thinner than 0.049-in.

The greater durability of an aluminum-copper tube is due, first, to the resistance of aluminum to the corrosive influence of impurities in cooling water, especially sulphuric acid and sulphates, and secondly, to the galvanic action induced between the two metals after the aluminum lining is finally perforated. Aluminum, being electro-positive to copper, protects it from corrosion in somewhat the same way that even porous galvanizing protects iron. No corrosion of the copper will take place until the aluminum has been entirely eaten away for a considerable distance around the perforation, thus leaving a sound tube for a much longer time than is the case when brass or copper is used alone.

In the accompanying figure, "A" shows how corrosion commonly pits a brass or copper tube, while "B" and "C" show how, under equal amounts of corrosive impurities in cooling water, a bimetallic tube has the copper envelope preserved for a long time, the corrosion being confined to the aluminum.

A practical demonstration of the superior qualities of these tubes is found in the experience of one of the large manufacturing concerns near Pittsburg, and on the Monongahela River.

In that locality brass or copper tubes are sharply attacked by the sulphuric acid and sulphates present in the cooling water. Ordinary brass tubes were found to have but a short life, and only mediocre results were obtained with copper tubes, tinned on both sides. Some 2,000 14-ft. lengths of standard No. 16 gage copper-aluminum tube were installed. Some of these



tubes have now been in use for about 22 months, the balance for varying lengths of time, but in every case longer than ten months. There has not been a single case in which a bimetallic tube has had to be replaced through any failure in itself. This record should be taken in connection with experience in the same condenser with tinned copper tubes, many of which required to be replaced within one year from the date of insertion and all of which were expected to give out and to be replaced within three years. With other installations of these bimetallic tubes in condensers where both salt and fresh water are used as cooling agents, there has not been any reported instance of failure. In nearly all cases the conditions of service have been extreme and tests have extended for varying terms of six to twelve months.

Having shown the greater durability of such tubes, there remains to be considered the comparative effects of the copper-aluminum combination upon the design of a condenser and upon its efficiency.

As it is primarily the purpose of condensing apparatus to maintain a high vacuum and secondarily, but of nearly as great importance, to deliver condensed steam to the hot well at high temperature, any feature of the material parts that will facilitate the accomplishment of either object is of appreciable value. The efficiency of a surface condenser is mainly dependent upon the following five factors:

(1) The temperature difference between steam and cooling water.

(2) The speed with which the cooling water circulates.

(3) Vertical or horizontal position of tubes, the latter giving better service on account of more easily being freed from the condensed steam.

(4) The thermal conductivity of the wall of the tube—B. T. U. per sq. ft., per second, per degree of temperature difference.

(5) The surface efficiency of the tube, which practically amounts to the ease with which it becomes coated with oily or mineral incrustations.

It is apparent that the first three considerations are not affected by the material of which the tubes are made, whereas the fourth and fifth considerations differ to a certain extent with the nature of the tube. The rapidity with which a thin section of metal will transmit heat has been the subject of considerable experimental work by many physicists, who have had at their disposal various kinds of apparatus for making thermal efficiency tests. The results differ so widely that it is doubtful whether much credence can be given to any one authority.

The classic tests of B. F. Isherwood (Kent's Handbook, p. 472) indicate that, within limits, the rate of the transmission of heat through a metal wall is independent of its thickness. The thicknesses used were ⅛, ¼ and ⅜-in. Tests, by the same authority, of the relative thermal conductivity of metals show that approximately 87% as much heat can be transmitted in a given length of time through a brass tube as through a copper one. Later investigations, by others, show that, in the case of good conductors—taking copper as an example, an increase in the thickness of the transmitting metal shows a certain but very slight decrease in the volume of heat carried. In the case of poorer heat conductors, such as iron or lead, the difference in conduction for a similar increase in thickness shows a much greater percentage. The poorer the conductor is, the greater is the percentage drop in efficiency of conduction due to increased thickness.

Other investigations indicate that the thermal efficiency of metals closely approximates their electrical conductivity, good electrical conductors having excellent capacity for transmitting heat and poor electrical conductors having less capacity, the difference being measured approximately by their relative electrical conductivities. Taking all these facts into consideration, a bimetallic tube of copper and aluminum has an efficiency of heat transmission considerably higher than brass and somewhat less than copper. Whatever advantage there is in the matter of heat conductivity lies in favor of a bimetallic tube as compared with the usual brass tubes. The difference in heat conductivity of the metal makes comparatively slight difference in the efficiency of the condenser, however, as the metal itself provides only a minor portion of the resistance to the passage of heat.

The amount of oily, saline or other incrustations that gather on condenser tubes reduces their capacity for transmitting heat 60 to 70%; that is, a tube in actual service with a normal amount of scale deposited on it cannot be depended upon for a thermal efficiency of more than one-third what would be acquired if the tubes were perfectly clean. The tendency of metals to gather scale depends largely on smoothness of surface. Rough iron tube gathers accretions more readily than a smooth surface. As practically all condenser tubes are drawn through dies there is nothing that can be said in favor of any one kind on the score of liability to gather scale.

To compare tubes take a condenser receiving 10,000 lbs. of steam per hour, maintaining a vacuum of 25.85 ins. of mercury and using cooling water at a mean temperature of 90° F. Whitham's formula for condensing surface is convenient to use here. (See Trans. Am. Soc. M. E., Vol. IX., p. 431; Whitham's "Steam Engine Design," p. 283; Kent's Handbook, p. 840.) The formula is:

$$S = \frac{W L}{c\ k\ (T_1 - t)},$$

where,

S = condensing surface,

L = 1,026 = latent heat of saturated steam at T_1,

W = 10,000 = lbs. steam condensed per hour,

*The Aluminum Co. of America, Pittsburg, Pa.

k = specific conductivity = 557 B. T. U., for brass = 610 B. T. U., for aluminum-copper tubes,

e = efficiency of condensing surface, taken as 0.323 by Whitham to represent normal operating condition.

For brass, then,

$$S = 1{,}571 \text{ sq. ft.}$$

For aluminum-copper,

$$S = 1{,}435 \text{ sq. ft.}$$

That is, 136 sq. ft. less are needed with the bimetallic tubes than with brass, for a given effect. The use of the new tubes to replace old brass ones yields a net gain in the efficiency of the condenser as well as a longer life of tubes.

A Bulletin Board for the Drafting Room.

By ARTHUR H. MORSE.*

In every modern drafting room frequent use is made of tabulated information in almost endless variety. The nature of the work carried on determines the kind of information required but, whatever the work, the tables are almost constantly in demand and any expedient which serves to make needed information quickly accessible helps to increase the efficiency of the office. It is common practice to supply each draftsman with a set of "standards," usually comprising more or less complete instructions in regard to lines, letters, dimensions and arrangement of drawings, and sometimes including tables of standard or commercial sizes of bolts, screws, pipe and similar articles, also weights of materials, mathematical tables, etc. Large offices often have, in addition, a bulletin board or "poster" on which may be found tables similar to those contained in engineers' hand-books, as well as tables or diagrams of special information of local interest, such as lists of jigs and templets, operation-symbols, materials carried in stock, etc.

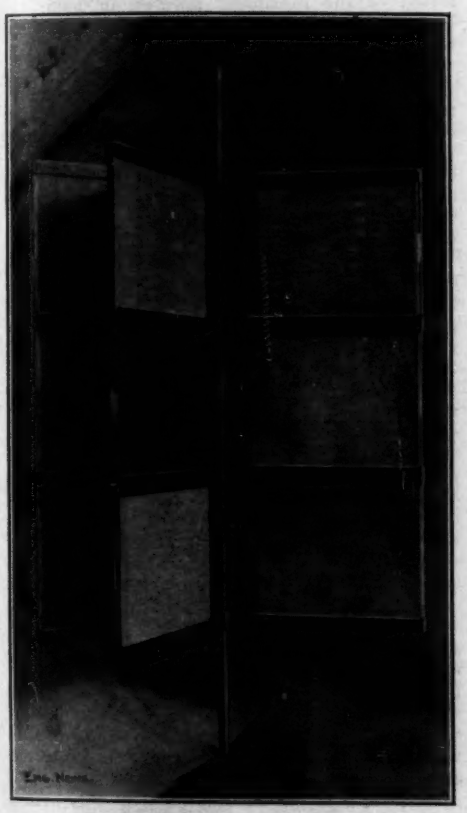


Fig. 1. A Hinged-Leaf Bulletin-Board For the Drafting Room.

The purpose of this article is to describe a form of bulletin board designed by the writer to suit the conditions in his office. It has been in every way satisfactory and is believed to have some advantages over the usual types, especially for an office of small or moderate size. Its chief advantage results from the fact that any table may easily be removed from the board for use at a desk, and as easily replaced; while every table is also perfectly accessible without removing it.

The bulletin-board consists of a number of leaves, on hinges, designed to swing around a central rod as shown in Fig. 1. The hinges are so spaced that the leaves are all at the same height. Details of construction are given in Fig. 2, which shows a leaf with panels intended to receive cards 8 × 10 ins. in size. The tables, or sheets, are mounted on cardboard and inserted in the grooves of the molding on either side of the leaf. For mounting, No. 30 binders' board gives good results. To prevent warping, a sheet of paper must be pasted on the back as well as on the front of the mount. Cards intended to serve permanently have been given a binding of sheet tin as shown in Fig. 3. A thin coat of white shellac over the face of the card will not affect its legibility and will keep it from getting dirty. The cards used are all blue-prints from tracings which are kept on file, so that any card which becomes mutilated or destroyed may be replaced.

Fig. 1 shows a bulletin-board of four leaves with a capacity of 24 cards. The spacing of hinges shown on the drawing is such that six leaves may be used if greater capacity is required. A still larger number might be used if necessary. The central shaft is cold rolled steel ⅝-in. in diameter with a set collar for the lowest hinge to rest upon. The shaft is held at top and bottom by any suitable wooden bracket.

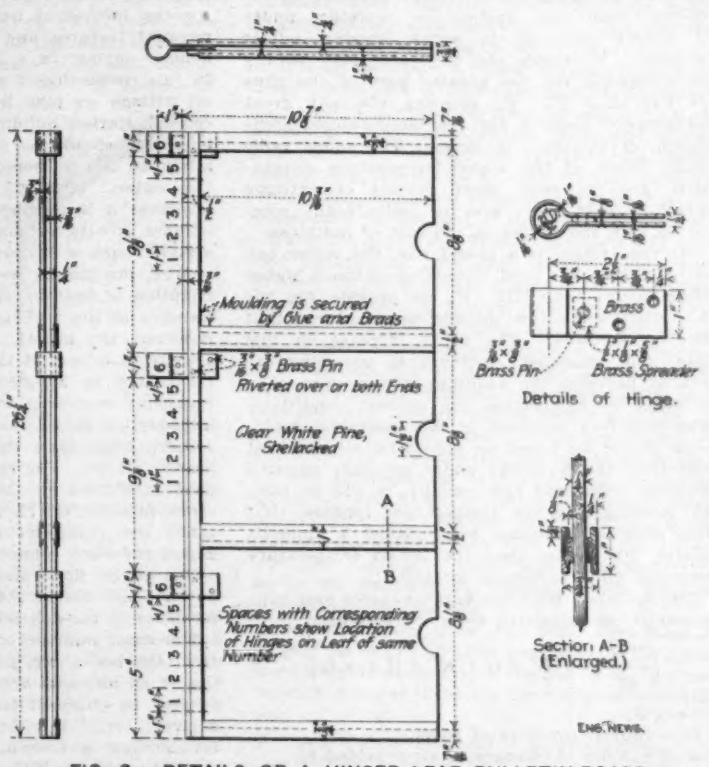

Moulding is secured by Glue and Brads
Brass Pin Riveted over on both Ends
Clear White Pine, Shellacked
Spaces with Corresponding Numbers show Location of Hinges on Leaf of same Number
Brass
Brass Pin
Brass Spreader
Details of Hinge.
Section A-B (Enlarged.)
ENG. NEWS.

FIG. 2. DETAILS OF A HINGED-LEAF BULLETIN-BOARD.

*Chief Draftsman, The Portland Co., Portland, Me.

Design of a Central Heating System with Forced Circulation of Hot Water.

By JOSEPH T. MAGUIRE.*

The following very general summary, of a method of designing central heating systems with forced circulation of hot water, is based on the actual designing of a number of such systems. This brief presentation should be of use to engineers whose experience has been along other lines but who have occasional need of knowing the approach to such problems. The writer believes the presentation is simple and more direct than any method that can be found in text-books. There are four points of novelty in an installation designed as shown.

(1) The radiating surface installed by most designers is taken the same for forced hot-water circulation as for gravity flow. Here the total heat given off per square foot of radiator is taken at a high value, 250 B. T. U. This gives a reduction in the initial cost of the system of at least 10%.

(2) The compressed-air expansion tank, to prevent the loss of water from the system by volume fluctuation, has been used with great success in two or three large systems, designed by the writer. Its use here is believed to be a feature unique to most engineers.

(3) The throttling of mains to equalize friction in branch pipes is, to the best of the writer's knowledge, also unique in this application.

(4) Some designers plan their system for continuous use at the very extreme of cold weather. The writer here has designed for the prevalent low temperatures and it is intended to carry the few abnormal drops of short duration by slightly overloading the system. The writer believes this is a good engineering principle, provided the designer can assure himself that his system can transmit the required additional heat for short times; that is, has the required overload capacity.

*Designer, Bureau Yards and Docks, Navy Department, Washington, D. C.

The writer cannot here discuss the relative merits of the so-called vacuum steam, high-pressure steam or forced hot-water circulation systems for large central heating installations further than to state that, in making a choice among these systems, four points need to be carefully investigated for each case in hand. These are: (1) first cost; (2) operating cost; (3) flexibility and cost of additions; (4) degree of possible centralization of all working parts.

For the purposes of this article assume that a forced circulation of hot-water will be used. It is circulated through out-flow and return pipes to radiators and coils in the various buildings to be heated. The circulation in the mains is forced by a circulating pump at the central plant. The circulation in the individual buildings depends, (1) on the difference in weight of the entering and leaving water, (2) on the difference of pressure between the supply and return pipes, and (3), on the frictional resistance of the piping and radiators.

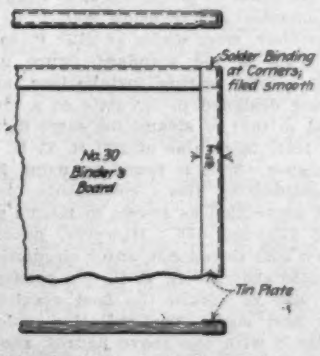


Fig. 3. Method of Binding Bulletin Cards.

It is good practice to assume that the hot water will be circulated at an initial temperature of 212° F. when the outside temperature is at a selected minimum. This allows the use of

radiators of the same size as those ordinarily installed for low-pressure or exhaust steam heating. The calculation of the radiation on the basis of circulating the water at a lower temperature than that suggested above is not to be recommended, as it unnecessarily increases the sizes of the radiators to be installed.

If it is considered that the radiating surfaces are figured to heat the rooms to 70° F. with a selected minimum outside temperature as an extreme, then the system is working under a lighter load, so to speak, during milder weather. Therefore the hot-water may readily be circulated for the greater part of the time at less than 212° F., securing the only great advantage, claimed for low-temperature circulation, of smaller line losses. The added radiation losses of the higher-temperature circulation, are for such short periods of extreme weather, that their sum is insignificant compared with the saving in the cost of radiators.

As the system is a closed one, the water can be, and often has been, circulated at much higher temperature than 212° F., to provide for the few abnormally low outside temperatures that are encountered. The rapid increase in line loss, and consequent increase in operating expenses, prevents the adoption of these figures as a basis of calculation for normal conditions. The radiation installed in the individual buildings should be based on supplying all the heat lost from the buildings under normally extreme weather conditions and, usually, it will be seen, by investigating the temperature records, that this selected minimum temperature is approximately 10° higher than the lowest temperature recorded for a particular locality.

The heat loss from the various rooms may conveniently be calculated from the formula:

$$\left(\frac{n\,C}{55} + K\,W + G + K'\,A\right)\left(t - t_o\right)$$

in which

C = cubical contents of room,
n = number of changes of air provided for,
W = net exposed wall area, deducting glass area,
K = constant for varying thickness of walls,
G = area of windows and doors,
A = area of floor or ceiling exposed to outside temperatures,
K' = constant for various types of floors and ceilings,
t = the required temperature of room, usually 70° F.,
t_o = selected minimum outside temperature.

The constants K and K' are those developed by the late A. R. Wolff, in 1893, and are given in Kent's pocketbook, seventh edition, p. 534.

This heat loss, divided by 250, will give the required radiation to be installed, as each square foot of radiation will transmit 250 B. T. U. per sq. ft. per hour, from water at 212° F. to air at 70° F. This is the standard figure used in nearly all steam heating installations, and the water being designed to circulate at a temperature equal to that of steam, the same figure applies. In fact, this value of 250 B. T. U. should be 10% higher. This is found by using Péclet's tables, modified by Box's coefficients for radiation and convection as shown in Kent's pocketbook, pp. 473 and 475. However, practice in both steam and forced hot-water circulation has demonstrated that 250 B. T. U. is a conservative figure to use to secure the best results at a minimum first cost. The radiation, calculated in accordance with the above figures, should be increased, for different exposures, according to the judgment of the designing engineer, but should approximate the following additions for the exposures named, when such exposures are of a severe nature:

20% for north.
15% for west.
10% for east.

Radiators should always be placed under windows, except in some cases in residences, where they would interfere with the desired draperies. If the supply pipes are run exposed, on basement ceilings, all basement radiators should be suspended from ceilings and should be pipe coils or radiators of the wall type properly bushed to allow perfect drainage of the entire system. In small installations the radiators may be placed beneath the supply and return pipes in buildings, but actual practice has demonstrated the unreliability of such practice for large installations, at least.

The radiation surfaces having been determined and located, the next step is to lay out the piping for the individual buildings. This presents no unusual features and should simply follow the general layout of a gravity hot-water system. In this connection it might be well to state that all fittings on pipe lines, both for mains from central station buildings and for mains within buildings, should be of the long-radius type, to minimize the frictional resistance to the flow of the water. It might, also, be suggested that wherever it is possible to install a loop system, without greatly increasing the cost over a branch system, such a layout would give much better results, precluding, as it does, the unequal distribution of heat by an unbalanced frictional resistance in the various parts of the system. If, however, the initial cost of such a system is greatly in excess of the branch system, the latter should be adopted and the equalization of frictional resistance should be secured by the introduction of suitable throttling devices on the returns from each building and on each main branch return. For this purpose, the writer has used manifolds on these returns, with a sufficient number of 1½-in. pipes, and valves, to equal the cross-sectional area of the pipe to which they are connected.

The main flow and return pipes from the power-house to the individual buildings, are determined in the following manner.

The total number of heat units, to be taken from the hot-water, per hour, in any one building or on any one branch needs to be obtained. It may be obtained from the figures previously derived, or, if the total radiating surfaces for the section is known, it is perhaps easier to multiply this by 250. To this final figure 10% should be added for all branches, to provide for the radiation from mains. This figure, divided by 30 (the drop in temperature usually assumed, between the supply and return mains), will give the pounds of water required, per hour, as each pound of water gives off, under the assumed drop in temperature, 30 B. T. U. Water, at temperatures between 180° F. and 212° F., weighs, approximately, 60 lbs. per cu. ft. Therefore, dividing the pounds of water per hour by 60, we have the number of cubic feet of water it is necessary to circulate, per hour, through the building or branch in question, to heat the rooms to the required temperature. Dividing this result by 3,600 we find the cubic feet required per second. Assuming a water velocity of 8 ft. per second (that velocity which will give the highest efficiency to the type of pump usually installed), we can immediately calculate the cross-sectional area of the mains, and specify the nearest standard pipe. The supply and return mains are, of course, of the same diameter.

Great care should be taken, in laying out the system of main flow and return pipes, to provide proper means for expansion and contraction. Expansion joints of looped pipes should be installed, not over 300 ft. apart. All mains, where branches are taken off, should be firmly anchored by pipe bands and fastenings extending approximately 9 ins. into concrete footings under the conduits in which the pipes are run. Anchors of a similar nature should also be placed between expansion joints on straight runs. It is hardly necessary to more than remind any one that all piping underground should be insulated according to the best practice and that valves should be installed in such a manner as to allow any branch to be cut out without shutting down the plant.

The radiation surfaces and piping having been disposed of, the next step is the design of the central heating units, which consist of an expansion tank, centrifugal pumps and exhaust and live steam heaters.

The expansion tank is to take care of the increased volume of water due to the rise in temperature of same and also is to serve as an indicator of the amount of water in the system. It should be connected to the main return pipe of the system, just before the return connects with the pumps, and it should be provided with a loaded piston or a connection to an air compressor of sufficient capacity to maintain, constantly, a pressure equivalent to at least 5 ft. in excess of the static head on the system. This precludes a common possibility of the water level in the highest radiators of the system being below the tops of the radiators. The size of the tank will depend largely upon the space available for its installation as well as upon the radiation surface of the system. In installations up to 20,000 sq. ft. of radiation, the volume of the expansion tank may safely be made equal to 5% of the total volume of water in the system. If it is assumed that the minimum temperature of the water, at any time it is allowed to remain in the circulating system, is 40° F., then this size of tank will care for all variation in volume up to that for 280° F., without admitting air to the system at low temperatures or spilling water at the high. Where it is safe for the designer to consider the minimum temperature raised or the maximum lowered, or both, the capacity of the tank may be reduced to care only for the expected expansion of the water. In very large installations, a 5% capacity is out of the question. The expansion tank should be provided with a gage glass that will show every possible condition of water level. There should also be a pressure gage, automatic overflow connection to the sewer and a drip connection with a hose nozzle. The proper location of the tank is, of course, in the central plant near the remaining heater apparatus.

In installing the pumps, provision should be made for breakdown service. This can be done by having two units, each capable of circulating two-thirds the normal supply at 212° F. The pumps, as previously estimated, carry the water to and from the various buildings, it being intended that the circulation within the buildings should be due to the difference in specific gravity of the supply and return water. As the system is closed, the static heads on supply and return pipes are balanced and the pump motor need be of only such horsepower capacity as required to overcome the friction head of the piping system. The frictional resistance and head, for various velocities, may be worked out according to methods laid down in hydraulic treatises or engineers' handbooks. Great care needs to be shown, however, in choosing the power-capacity of the pump drive to allow for any additions to the heating plant that may be expected in the near future. The questions of whether the rotary pumps are to be engine or motor-driven depends on the particular conditions under which each individual plant is designed.

The last point to be considered in this article is the heater itself. There is a great diversity of opinion about the size and character of the heater to be used. The writer is strongly in favor of using one or more exhaust steam heaters, arranged to operate singly or in series, with a live-steam heater connected as a "series booster" for either or both of the exhaust heaters. The use of exhaust heaters simply limits the maximum temperature of the water supply to rather less than 212° F., depending on the size and amount of heating surface. To keep the supply temperature at or above 212° F., live steam may be introduced into the exhaust-steam heater, through a reducing valve, but this expedient throws back pressure into the engine exhaust and is to be avoided wherever possible.

A heater of sufficient size to heat the water supply with exhaust steam and of sufficient strength to allow the introduction of live steam at high pressure, would be of expensive design, both in first cost and operation. A more satisfactory and cheaper installation results by separating the units. The principal advantages of having two types of heaters are: (1) that the water may be circulated at as high a temperature as 240° F. for abnormally low temperature

outside, without throwing any back pressure on the engines; a sudden drop in temperature outside can quickly be compensated for; and (2), in case a time arrives when no exhaust steam is available, the whole system can be taken care of, temporarily, by the live steam heater.

Both types of heaters consist of cylindrical steel shells with dished or bumped heads, bolted on and with charcoal iron tubes expanded into steel-plate partitions separating the cylindrical portion from the heads. Usually, the water space consists of the two heads and the connecting tubes, and the steam space is the cylindrical portion around the tubes. The reverse condition would be mechanically satisfactory, but would not allow as efficient a design. Several investigators in years past have found that the heat transmitted in condenser tubes is much greater with the steam on the outside of the pipe than on the inside.

In exhaust steam heaters, it is customary to assume the temperature of the return water, under maximum supply conditions, as 180° F., the temperature of steam at 212° F. and the heat transmitted per degree difference between the two mediums as 160 B. T. U. per sq. ft. of water surface per hour. Therefore each square foot of tube surface transmits 5,120 B. T. U. per hour. Ordinarily the value used is 5,000 B. T. U. The tubes are commonly 1½-in. in diameter and are spaced far enough apart to give a clear space between for the steam. At the same time, they are spaced far enough apart to prevent weakening the partition plates, into which they are expanded. The number and length of tubes are arranged as the designer thinks best, the necessary area being found by dividing the total B. T. U. to be supplied per hour by 5,000.

The live steam heaters are proportioned in a similar manner, the sole difference, as to size, being the transmission of heat per square foot of tube surface and, of course, this will vary with the pressures used. With steam, at 10 lbs. pressure, on the outside of the tubes and with water at 180° F., on the inside, 270 B. T. U. per sq. ft. per degree per hour has been found as the transmission figure. With steam at 60 lbs. pressure this value rises to 349 B. T. U. These results are discussed in Kent's handbook, seventh edition, p. 473.

Thickness of shells, riveting, etc., are found by following standard boiler practice and computation. These details need not be considered here.

Pressure gages should be placed in the supply and return mains, inside the central plant. Thermometers should be placed in each supply and return connection of each heater. The heaters should have air valves, drips and any safety or relief attachments which the designers find desirable for each design in hand.

Braced Sheet-Pile Revetment Wall of Reinforced Concrete.

A braced sheet-pile retaining-wall, built wholly of reinforced concrete, has been used to some extent in the harbor slips of Duisburg, Germany. The construction is intermediate in cost and service value between a simple paved slope-wall and a vertical quay or bulkhead wall. Where it is used the river carries much scow or canal-boat traffic, and the shallow revetment described is sufficiently deep to enable these boats to moor close along the wall, as for unloading. The drawing Fig. 1, herewith, and the view Fig. 2, taken from the "Zentralblatt der Bauverwaltung," show the finished construction, but require some explanation as to the method of building.

The line of sheeting consists of reinforced-concrete slabs or sheet-piles 4¼ ins. thick and 24 ins. wide. The bottom is of gravel, so that the piles did not need to be driven very deep. The sheet-piles are only 13 to 15 ft. long; alternate ones were driven a foot or two deeper than the intermediate ones. As a brace support for the wall, batter piles were driven on both water and land side. These form triangular bents, spaced about 20 ft. apart along the wall. They are also of reinforced concrete. The front piles were molded 10 × 12 ins. in section. The rear piles are 10 × 10 ins., but have barb-like enlargements to give them greater resistance to forces tending to pull them out. These brace piles were driven several feet deeper than the sheet piles.

After the pile work was completed, the upper ends of all piles were stripped of concrete so as to leave the reinforcing rods projecting. These were bent toward each other, and connected with a set of longitudinal rods (parallel to the wall of sheeting). A longitudinal concrete beam was then molded over the top of the wall, extending across the heads of the brace piles, and enclosing the longitudinal rods. The top surface of

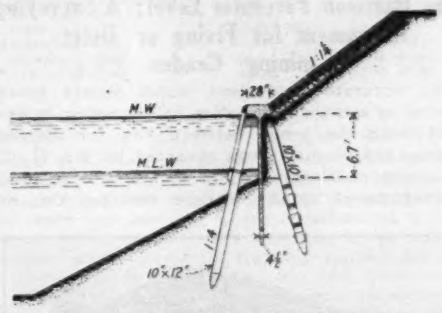


Fig. 1. Cross Section of Reinforced-Concrete Sheet-Pile Revetment Construction.

this beam is straight, while the under face is arched longitudinally, which acts to stiffen the brace piles.

The longitudinal beam supports the slope-paving of the bank above, distributes the earth pressure against the sheet piles to the brace-pile bents, and gives a bearing surface for vertical loads. At some points cantilever unloading cranes of gantry type run along the wall. The forward track rail in these cases is laid on the concrete beam, while the rear rail is at the top of the bank. At other points a timber wharf is built over the slope, its front posts resting on the concrete beam.

Fender timbers are bolted along the front face of the beam and along the front brace piles, to protect the concrete from the impact of freight scows.

The Montreal Convention of the League of American Municipalities.

The League of American Municipalities held its thirteenth annual convention last week at Montreal, the proceedings occupying three days. Of some 200 cities which hold membership in the League, about 50 sent official representatives. As a city can send as few or as many delegates as it pleases, the number present from a given city varied from one to three dozen or more.

Fig. 2. View of a Section of Concrete Sheet-Pile Revetment; Harbor Slips of Duisburg, Germany.

About 400 or more were registered in attendance at the convention, including ladies and other guests, and the number of delegates at the sessions ran from 50 to 150.

The Commission Plan of City Government.

Of the subjects discussed at the meeting, that which attracted most interest was the commission form of municipal government, frequently known as "the Galveston plan" or "the Des Moines plan." One of the papers before the convention, by Mr. Clinton Rogers Woodruff, of Philadelphia, stated that nearly 50 cities are now using the commission plan in some form or other or have measures under consideration looking to its adoption.

A notable paper was read by Hon. Grant Conrad, Mayor of San Diego, Cal., where the commission plan was adopted last spring. Mr. Conrad gave instances where the city, under the new form of government, was receiving far more for its money, buying supplies in some cases for one-third their cost under a former regime. The Commission plan had, in that case, he said, destroyed the power of the political machine which controls all public affairs in California. As a part of the plan there was adopted the initiative, the referendum, and the recall, so that the voters have the power promptly to remedy any neglect or incompetency on the part of their elected officials.

While the prevailing opinion among those who read papers and took part in the debate was strongly in favor of the Commission plan, there was also evident a certain undercurrent of opposition, and disbelief that the new method of Government could accomplish more or better results than the old, as soon as the new wears off. Especially strong was the opposition to the idea that the same officers who have the spending of public money should also be responsible for its appropriation. The charge was indeed made that the new Commissions were accomplishing things merely by spending much more money than their predecessors, and that not until the Commission form of Government had been in use for a considerable number of years would the real facts as to the extravagant results of this form of government be revealed.

Notwithstanding these and other criticisms, it is safe to say that the delegates as a whole went home impressed with the merits of the Commission plan, particularly for cities of moderate size.

State Public Service Commissions.

A topical discussion on the subject "Regulation and Control of Local Public Service Corporations by State Boards" brought out an interesting situation with respect to the movement to establish State Public Service Commissions, similar to that in New York, in other states. In the Northwest, particularly, it appears that the cities and the rural districts are ranged in opposition on this question. The cities desire to control the public service corporations themselves without aid or interference from state authorities. Some of the city officials present at the convention declared that the present popular sentiment in favor of corporation control by state commissions has been shrewdly taken advantage of by the corporations themselves, which are engineering the movement now for their own advantage. They aim to have the control over municipal franchises lodged in the hands of a State Commission in such a manner that corporations using the public streets may obtain privileges in them for an indefinite time and not be obliged to bargain with city officials for renewal of expiring franchises.

Another clash of interests comes between the city and the state authorities over the revenues from public utility companies. In Minnesota, for example, the state legislature, in which the rural districts control, seeks to tax the gross earnings of all public service corporations, including those operating in large cities, and bring this tax into the state treasury. The Minnesota cities, however, contend that if their street railways and electric companies are to be permitted to charge rates high enough to pay a heavy tax on gross earnings, then the tax ought to go into the treasury of the city whose people patronize the street cars or buy the electric current.

In Illinois, it was pointed out that the efforts of the Chicago franchise grabbers had all along been to have the legislature at Springfield take away Chicago's right to control its own franchises.

It developed, however, in the course of the discussion that few of the delegates had any clear understanding of what the New York Public Service Commission law really is, or how it is

actually operating. Mr. Harry P. Nichols, head of the New York City franchise bureau, explained that the up-State Commission in New York has authority only over the rates and methods of operation of public service companies and has no authority over the grant or duration of municipal franchises. The work of the Commission was further defended by Mr. Logue, of Poughkeepsie.

Municipal Revenue.

The subject of municipal taxation occupied considerable time. The trend of opinion of the principal speakers was against the assessment of personal property for taxation. To supplement the revenue from real estate, several cities are now assessing a wheelage tax on all vehicles which use the streets, the income from which goes to the street repair fund. Baltimore assesses an annual tax of $2 on each one-horse vehicle and $4 on each two-horse vehicle. This tax has been in force 25 years. Kansas City has a tax of $5 on automobiles and $3 and $1.50 on two-horse and one-horse vehicles. Charleston, S. C., taxes vehicles used for business purposes, but exempts those for pleasure. All these taxes are, of course, in addition to the general tax assessed on the vehicles as personal property.

Some cities derive revenue from licenses for projecting signs, bay windows, etc. It was suggested that Milwaukee, famous for its beer production, ought to be able to derive large revenue from the numerous "bay windows" on the streets.

Roanoke, Va., allows no signs to project over the streets except signs made up of electric lights. These must not have less than a certain illuminating power per square foot of sign and are then permitted free on account of the street lighting service performed.

Hon. C. R. Robb, City Treasurer of Montreal, who read an able paper, suggested that taxpayers ought to look at what they received in return for their taxes instead of what taxes they paid. He declared that money raised by taxation and wisely and economically spent for public purposes gives the citizen a far greater measure of benefit than he could obtain by spending the money for himself. For example, the city resident has a better water supply furnished his dwelling than the average country dweller could obtain even by the expenditure of a much greater sum.

Many cities have derived considerable revenue from liquor license fees. With the spread of prohibition, this revenue is bound to fall off. In Atlanta, Ga., the saloon licenses formerly brought $135,000 a year to the city treasury. The whiskey dealers have gone out of business; but in their place "near-beer" saloons have sprung up, the courts have declared the beverage lawful and the revenue from their licenses is now about $35,000 per annum.

Miscellaneous Business.

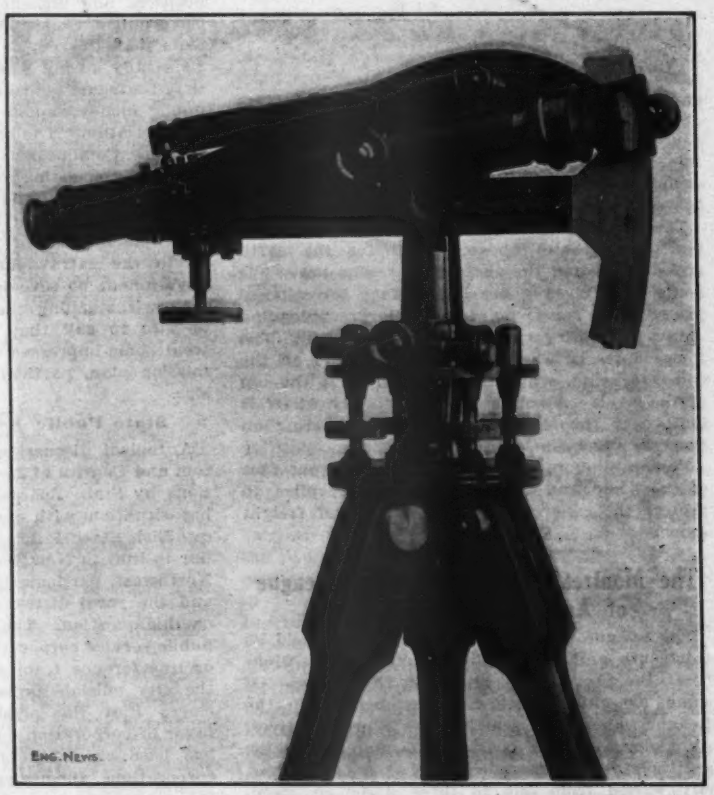
Among the other subjects on which papers were read or discussions took place were public playgrounds, municipal problems of the South, city improvement leagues, women suffrage and the unemployed. Concerning the first and last of these it was remarked that "the playless boy is father to the job-less man."

The election of officers and the choice of a place for the next annual convention appeared to interest the delegates more than any other part of the convention. The Presidency finally went to Hon. David Heineman, Alderman, of Detroit, who was First Vice-President of the League last year. Mr. John MacVicar, Superintendent of Streets of Des Moines, was re-elected Secretary. St. Paul won the race as next year's convention city.

The City of Montreal entertained the delegates in royal fashion. They were taken on steamer excursions on the St. Lawrence, through the Lachine Rapids and about the harbor, and on trolley excursions to Dominion Park, a local amusement resort. A carriage drive through the city to a garden party in Mt. Royal Park on Friday afternoon wound up the program.

The Harrison Percenter Level; A Surveying Instrument for Fixing or Determining Grades.

An accurate instrument which should prove useful in establishing points on grades or in ascertaining the grade between two far distant points has recently been invented by Mr. D. C. Harrison, of Washington, D. C., and is now being manufactured by the Eugene Dietzgen Co., of New York. The principle of the instrument, which is known as the Harrison Percenter Level, is that of a telescope mounted to move in a vertical plane upon a pivot at the eye-piece end, the angle of movement being measured by a graduated scale at the object-glass end. Instead of the usual graduation to degrees common on all vertical angle instruments, the scale on the Percenter is graduated to percentages of grade, so that with the proper setting the line of any grade can be followed through the line of sight of the telescope. It should be noted that the gradienter attachment to the ordinary transit is designed to accomplish this same purpose.



AN INSTRUMENT FOR FIXING AND DETERMINING GRADES.
(Invented by Mr. D. C. Harrison; made by the Eugene Dietzgen Co.)

Two styles of the instrument are being made, varying in workmanship, accuracy and price. In the accompanying half-tone is illustrated the more complete of the two. From this view the construction of the instrument may be readily followed. It consists primarily of a horizontal bar rigidly mounted on a center pin which sets on an ordinary wye-level base. On one end of this bar is mounted, in a vertical plane, the graduated percentage scale and on the other is a horizontal pivot which carries, moving in a vertical plane, the telescope. Mounted on this telescope is a curved bar which carries at its extreme outer end a glass-mounted guide which, in turn, is centered with the cross-hairs in the telescope and which moves on the graduated scale. Both the main cross bar and the telescope carry level bubbles. The telescope is moved up and down by the screw near the eye-piece end and is clamped in position by the clamp screw on the graduated scale. This scale is graduated up and down from zero to grades of 20 ft. per hundred at intervals of ½ ft. per hundred. Stadia hairs are provided in the telescope to measure distance when desired.

In operation the instrument is first leveled by each of the two bubbles, thus affording a check, and the cross-hairs then set on a target fixed at the height of instrument as determined by the instrument man. The grade between the two points is then read directly upon the scale. Intermediate points are then very easily set from the instrument.

With the aid of a table of tangents the ordinary vertical circle on a transit can be used for this same procedure, but the transit vertical circle is not always very accurate, nor is the radius of the scale as great as on the Percenter. The latter can be used to great advantage in such work as ditch digging, recovering lost grades, terracing, grading, etc. As an additional advantage, it can be used as a dumpy level when clamped to zero on the scales.

Wood Paving in Kensington, London, England.*

By WILLIAM WEAVER,† M. Inst. C. E.

Having, after 46 years' work, retired from my official position at Kensington, I am perforce prevented from taking an active official part in municipal matters, but I still follow with keen interest the continued advance in municipal work, and I have perused with pleasure the reports of the recent congress on road maintenance in relation to modern traffic.

In reviewing the changes of the last half century, road construction presents features of peculiar interest, and present-day methods, compared with those obtaining in the days of turnpikes, are as different as a banquet to a beanfeast, and during the period mentioned there has been a continuous advance in meeting public requirements.

In the proceedings of the Road Congress the subject of wood paving has not been dealt with to any considerable extent, and as this material has received my special attention since 1872, when it came into extended use, I have written the following particulars thinking they may be of some interest and use.

In May, 1882, I laid experimental areas of creosoted wood blocks, respectively 3, 4 and 5 ins. deep, jointed in different ways, and as the result of careful observation I advised my board to lay 4-in. creosoted deal blocks in Sydney Place, an omnibus route leading from Fulham Road to South Kensington station. These blocks were laid close, and grouted first with pitch and then with Portland cement, the work being carried out in November, 1889, and the blocks lasted until June, 1901, when the road was repaved in a similar manner.

Apart from the various systems of wood paving, patented and otherwise, I have had under observation during the past 30 years wood paving blocks of the following description—viz., plain deal, creosoted deal, jarrah, karri, Haskinized, Gardenerized, Jodolized, naphthalized, carbolized, red gum (Australian), red gum (American), tallow wood, black butt, black wattle, oak (American white), oak composite blocks, spruce, mora, wallaba and beech.

No useful purpose would be served by setting forth in detail the results furnished by the trials of most of the foregoing woods, but the conclusion at which I have arrived, after my experiments initiated in 1882, was that creosoted deal furnished the most suitable and economical road pavement; further, that 5-in. blocks lasted as long as 6-in., and that 4-in. creosoted blocks answered all the requirements of roads where the traffic is not excessive. In order to understand that a 5-in. will last as long as 6-in. paving, it must be borne in mind that wood paving must be renewed as soon as its general surface ceases to drain itself; and this happens when the blocks forming the haunches of the road are reduced between 1 and 2 ins. in depth, the channel or water-courses meanwhile not being exposed to similar traffic, suffer no diminution of depth.

The above conclusions are fully borne out by the accompanying table of instances, extracted from my annual reports, which furnishes details of 304,220 yds. of 5-in. and 137,164 yds. of 4-in. wood paving laid in Kensington since 1887.

*Condensed from "The Surveyor and Municipal and County Engineer" [London], July 2, 1909.

†Late Borough Engineer and Surveyor of Kensington, and Past President of the Institution of County and Municipal Engineers.

TABLE I.—DESCRIPTION AND LIFE OF WOOD BLOCK PAVEMENTS IN KENSINGTON, LONDON, ENGLAND.

Name of road.	Area, sq. yds.	Description of wood.	Date when paved	Life of wood.
Westbourne Grove and Archer Street	10,328	5-in. creosoted deal	Dec., 1887	20 years
		5-in. naphthalized blocks*	" "	10.42 "
		5-in. plain deal*	" "	6 "
		5-in. blocks dipped in creosote*	" "	10.42 "
Kensington High Street	1,714	4-in. jarrah	Oct., 1892	6.92 "
		4-in. creosoted deal	Sept., 1890	7 "
		4-in. red gum (American)*	" "	3 "
Kensington Road, between Hornton Street and Russell Road	16,550	5-in. creosoted deal	March, 1890	11.5 "
Kensington Road, from Russell Road to western boundary	1,528	5-in. creosoted deal	May, 1886	15.3 "
Brompton Road	13,183	5-in. creosoted deal	Sept., 1903	10.08 "
Old Brompton Road	25,307	5-in. creosoted deal	Oct., 1891	13 "
	3,200	4-in. jarrah	" "	8 "
Pembridge Villas	6,542	5-in. creosoted deal	May, 1895	Still down
		5-in. jarrah	" "	8.16 years
		5-in. karri*	" "	8.16 "
		6-in. red gum (Australian)*	" "	9.60† "
		6-in. Jodolized deal*	" "	9.60† "
Holland Park Ave.	18,846	5-in. creosoted deal	Oct., 1892	14 "
Sydney Place	3,509	4-in. creosoted deal	Nov., 1899	11.00 "
Cromwell Road	16,504	4-in. creosoted deal	Oct., 1900	Still down
Holland Road	16,160	4-in. creosoted deal	June, 1899	Still down

*Trial sections under equal conditions of traffic.
†Extensively patched in 1903.

In connection with No. 5 in the foregoing list an instructive comparison is furnished by the history of the wood laid in the Hammersmith Road in continuation westward of the area (No. 5) laid in Kensington; at the same time (May, 1886) Hammersmith laid down 6-in. plain deal blocks which lasted a little over six years, being replaced in July, 1892, with 5-in. jarrah blocks. After eight years the jarrah blocks were reversed and rebedded in July, 1900, and replaced with 5-in. creosoted deal in July, 1903. The 5-in. creosoted deal adjoining in Kensington, laid in May, 1886, lasted until September, 1901, equal to the combined lives (less than two years) of the plain deal and jarrah together.

Further, with regard to the above schedule, I may add that all the roads enumerated are omnibus routes, but the traffic on each, of course, varies in severity.

In conclusion, I would point out that by reducing the depth of the wood (each inch of reduction means over a shilling per yard saved), and, further, by about doubling the life of the wood by creosoting, wood paving need no longer be considered an expensive luxury, but must be regarded as a sanitary and economical substitute for macadam where costing over 8d. [16 cts.] yer yd. annually to maintain. At the same time, it must not be lost sight of that such substitution has a tendency to increase the rateable value of the abutting property owing to the improved appearance, cleanliness and quietude of the road.

Sewage Sludge Disposal at Brockton, Mass.

The use of a manure spreader for the disposal of sludge from the sludge beds of the sewage-purification works at Brockton, Mass., is briefly described and illustrated in the 1908 report of Mr. George E. Bolling, Chemist and Bacteriologist in Charge of the Laboratory of the Health, Water and Sewerage Departments of Brockton. The report also contains a brief history of sludge disposal at Brockton since the works were started some 15 years ago.

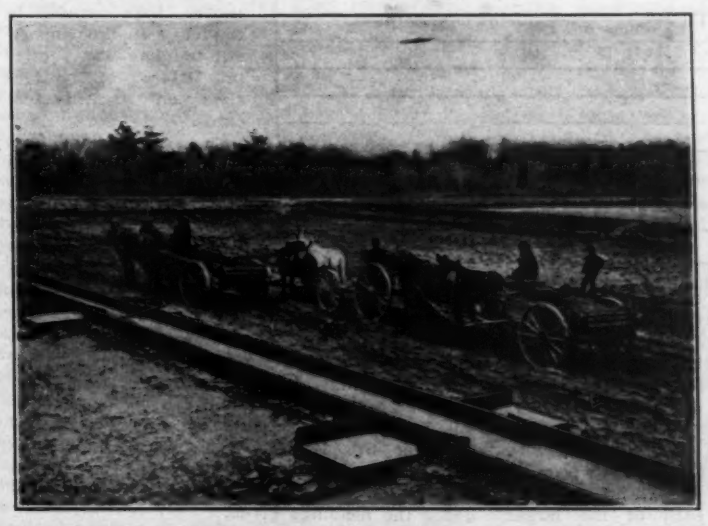
As stated in a lengthy illustrated article describing the Brockton sewage works, published in our issue of May 2, 1895, the sewage of Brockton is pumped from a receiving reservoir to an intermittent filtration area located at some distance from the reservoir and pumping station. The sludge which accumulates on the bottom of the receiving reservoir is stirred up by back pumping, and pumped to sludge beds at the disposal area. The liquid portion of the sludge drains through the beds and is purified to a greater or less extent, leaving a layer of comparatively dry sludge for removal and disposal. The extract from the report named is as follows:

A satisfactory final disposition of the deposit removed from the sludge beds has, until the past year, been lacking.

The sludge removed increased from 72 tons in 1896 to 3,422 tons in 1907; owing to the method of removal from the beds in 1908 the exact amount cannot be told for this year, but probably was not far from 3,500 tons. The size of the daily sludge dose received at the beds has increased from 70,000 gallons in 1896 to 136,000 gallons in 1908, while the solids shown by analysis have increased in the same time from 163.50 to 1,117.75 parts per 100,000.

During the first year of operation of the plant all rakings from the sludge beds were burned on wood fires in the open field, the smoke from this operation, however, being provocative of so much adverse comment from near-by residents that considerable relief was experienced when, in 1898 and 1899, the burning was discontinued and the experiment tried of giving the sludge to farmers who hauled it away for fertilizing purposes. The success attending its use produced a greater demand for it until, in 1900, the rakings for the entire year were sold by the Commissioners to the highest bidder for $125. The disposition of the sludge in this manner caused the indefinite postponement of plans for building a crematory at the filter beds.

In 1901 the price for the entire year's amount was fixed at $150, and this remained the annual figure until 1906 when the amounts removed from the beds had so increased as to be beyond the ability of the farmers to remove it readily and the charge for it was removed to encourage them to spend a little extra for help in removing the sludge promptly from the piles where it was dumped after being carted from the beds.



THE USE OF MANURE SPREADERS FOR REMOVING AND DISPOSING OF SLUDGE IN THE SEWAGE FILTER BEDS OF BROCKTON, MASS.

The past year the Commissioners have contracted with the nearest neighbor to the beds, in the town of Easton, to give the sludge free of charge for a period of five years, in consideration of its immediate removal from the plant at the time of cleaning the sludge beds. This agreement on the taker's part has been fully lived up to, thus preventing any likelihood of a nuisance being caused by any accumulation of sludge in piles at the plant, and moreover the practice of sending teams owned by this taker down into the beds where they were loaded by city employees has resulted in a considerable saving to the city, as the sludge beds were cared for for $310.89 less than the cost of the previous year.

The accompanying illustration shows the type of wagons used for the conveyance of the sludge by the taker, manure-spreaders, which also served to distribute it at the place desired without additional shoveling.

The sludge was used with corn, potatoes, millet, and other grass, and with each crop demonstrated its value as a fertilizer. With corn it appeared to give good results when used alone; with the other crops better results were obtained when potash and phosphoric acid—which essentials the sludge does not contain in like proportion with nitrogen—were added.

The composition of the rakings varied with the season, the moisture ranging from 5 to 50%. An average of several analyses is as follows:

Moisture	16.22%
Phosphoric acid	.78%
Potassium oxide	.51%
Nitrogen	1.45%
Calcium oxide	.50%
Insoluble matter, sand, etc.	70.13%

An Efficient Indexing System for a Civil Engineer's Office.

By WALTER A. BROWN.*

The indexing and filing of plans and data is a matter of increasing importance to an engineer in private practice as well as to a city engineer. Records and plans so multiply that the question of filing space becomes a serious one. Small engineering firms grow into large corporations and their records rapidly increase in value, provided the accumulated notes and plans are made available by a suitable index and file.

Several articles have recently appeared upon the subject in Engineering News, and other publications, showing that there is a wide variation in practice among different offices, and the same system is not readily applicable to all. A decimal system, designed by Mr. W. G. Taylor, Assistant City Engineer, Waterbury, Conn., and described before the Connecticut Society of Civil Engineers, Feb. 9, 1909, seems to be well nigh perfect, in its adaptability to indefinite expansion. All that is necessary is to learn to associate certain decimal figures with the corresponding class or subdivision. To make the best use of this index one must have in mind which of twelve figures in units place represents the subject (first subdivision) he seeks, and which of ten figures in tenths column represents the particular class or tertiary division.

The engineer, with a small practice, employing little or no help in the winter season and a large force, unacquainted with the system, during the summer, may find a system of indexing by subject matter directly more applicable to his needs. During the past few years, in connection with his work as assistant city engineer of Springfield, Mass., and in a few other places, the writer has devoted considerable time to a study of indexing, and presents herewith the results of his observations, modestly hoping that there may be some suggestion of value to a brother engineer.

The system evolved is similar to Mr. Taylor's decimal system, referred to above, in the use of tab cards for designating the secondary division, but instead of having printed on the tab a number representing the name of the subdivision, the name itself is printed on, thus enabling one not familiar with the system to use the index intelligently, without the aid of a key. The following subdivisions have been found convenient and sufficiently distinctive to enable the one who files the plans and indexes the book to judge at once which card to use in each case:

Street Lines, Property Lines, Railways, Conduits, Book, Profile, Structure.

These words, or abbreviations therefor, are printed in plain black letters on the tabs, as shown in the accompanying figure, one tab (the fifth position) being left blank to be printed by hand as wanted. The fifth-position tab card is reserved for use in indexing anything not properly classed under any of the printed headings, such as topography, specifications, catalogs, etc.

A brief typewritten explanation is kept with the blank cards so that when a new man in the office undertakes to index a plan, he may readily learn which tab card to select and fill out for that particular plan. For example, the explanation given for the "Profile" tab is, "Use this card for street profiles and similar drawings made on profile or cross-section paper."

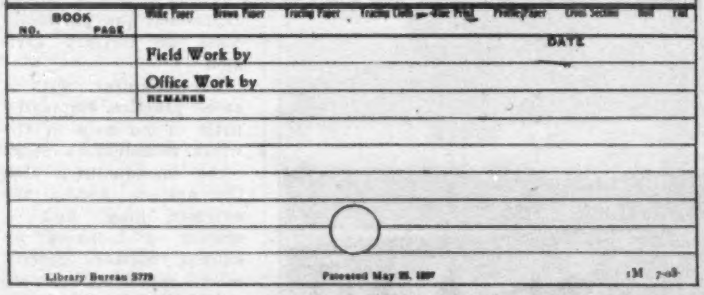
If desired, this secondary classification might

*Engineer and Treasurer, The Clapp & Abercrombie Co., Greenfield, Mass.

consist of more than eight divisions, a smaller tab being used and the size of the type on it reduced. Or additional cards of a different color, might be used, having tabs in these same eight positions, giving a total of sixteen subjects.

But is a minute subdivision desirable? The purpose of an index is not to classify plans, but rather to point out all available information on a certain subject, and too great a subdivision may result in missing the desired information through failure to look in the proper division. For instance, the above classification provides for placing the note book cards in the same drawers with the plan cards so that if one, in looking for certain information, did not know whether it was to be found among plans or field notes, he could not miss it through failure to look in the right index drawer.

The printing and ruling of all cards is identical, except as to tabs, thus the initial cost of printing the cards is reduced to a minimum. A further saving often can be effected by using stock alphabetical guide cards. In most cases, however, it will be good economy to either print by hand, or have printed, the names of all primary divisions on plain guide cards, cut fifths. These guide cards serve to guide the eye to the particular portion of the index desired.



A SET OF INDEX CARDS FOR A CIVIL ENGINEER'S RECORDS

If one is doing work in different towns, so that there are a large number of these primary divisions for each town, it is well to segregate the material relating to each of the larger towns under a guide bearing the name of the town, in which case the guide cards for the towns should be of a different color and more prominent.

To further mention the printing and ruling on the cards, it will be noticed that headings are given to guide the indexer in filling out the cards and to reduce as much as possible the labor and time required for the same.

The first line at the top is, of course, the name of a primary division of the index, and the word by which the card is to be placed in its alphabetical position in the drawer. It is perhaps most frequently the name of a street or individual; if it is a street, then on the next line, headed "Location," should be written the name of the town, or city. If the index is to cover work in various towns, or if there is to be no question as to the location of the street and it happens to be a long street, under "Location" may be written the names of two other streets defining the limits covered by the plan. This will be found very convenient in the case of a long street which appears many times in the index, for instance "Main Street" being the primary division or name written on the first line of the card, under "Location" might be printed "High to South Street, Greenfield."

The third line headed "Description" is, generally speaking, the place for writing out the title of the plan, but under this system it is frequently unnecessary to write out the title in full, as the plan is sufficiently described by the words already written on the card and those to be written under "Field work by," "Date," "Book, No. and Page," the idea being to avoid repetition and save writing on the card, thus reducing the labor of indexing to a minimum.

Just below the space for "Description" is printed the name of each different kind of paper to be used, as "white paper," "tracing paper," "tracing cloth," "blue-print," "profile paper," etc., also the words "roll" and "flat," with space under each of these words for a check mark indicating under which name the plan in question is properly classified.

The size and style of type, or script, used in making out the card has much to do with the utility and neat appearance of the index. The first line should be particularly plain, and for the sake of uniformity in size, gage lines should be used. The writer believes, however, in eliminating everything from the card that is unnecessary in order that the information desired may stand out more clearly. With this in mind, he has substituted for solid black lines to gage the index word, a few very fine dots placed in two horizontal rows just the right distance apart to guide the indexer in printing the first line on the card. This has been found to work very well, and when the card is finished the dots are not noticeable, and yet the general appearance of the index is much neater than would be the case if the important top line was printed in letters of various sizes on the different cards.

These cards have been found to serve the purpose admirably for either plans or books, and the saving in first cost of cards by having only one form to print is worth considering, to say nothing of the advantage of uniformity about the cards, so that one knows right where to find certain information and forms the habit of looking in that particular place on the card; thus the desired information can be found without reading the contents of several cards all through. Space is left below for additional remarks, but experience shows that the desired information can be recorded in very few words under the headings given.

The file number and the record number are always placed in the upper right-hand corner on the same line with the name of the primary division; the filing number being the index number, and consisting of the drawer and till number separated by a hyphen, the record number being the office, or accession, number of the plan, distinguishing it from every other plan. Either of these numbers may be used for identifying a plan in public records.

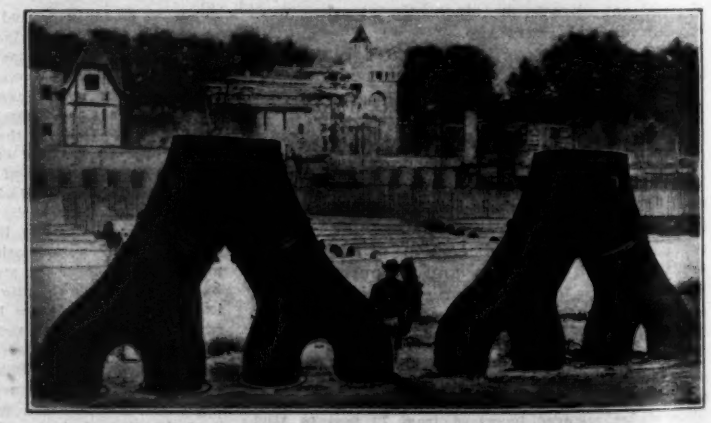
In connection with indexing, the writer has designed a system for filing plans, which makes it possible to get a maximum number of plans in a limited filing space, a matter of considerable importance where rental for vault room comes high and there are several thousand plans to be protected from possible destruction by fire.

MUNICIPAL PURCHASE OF WATER-WORKS owned by private companies is to be investigated in behalf of the New England Water Works Association by Mr. F. W. Dean, 53 State St., Boston, Mass. A list of inquiries regarding such purchases has been prepared and may be obtained by addressing Mr. Dean.

Reinforced-Concrete Pipe Specials Used in the Water Supply of Paris, France.

The accompanying half-tone, taken from the July, 1909, number of "Concrete and Constructional Engineering," of London, shows the reinforcing framework of two large specials used in a new reinforced-concrete pipe line addition to the water supply of the city of Paris, France. This main for the greater part of its 4½ miles length, is about 48 ins. in diameter and is designed to carry a 280-ft. head of water. The pipe is of the Bonna type, which consists of a middle cylindrical shell of ⅛-in. steel, reinforced on the outside with longitudinal and spiral bars and covered, inside and out, with a fine aggregate concrete. The sections of 14 ft. each are cast in a yard and provided with a special metal flange, which, when the joint is made after the pipe is placed in the trench, is covered with an external band of concrete reinforced with a short length of steel plate.

All of the specials on the line are constructed after the same system. And the one shown in the view is the reduction to 24-in. diameter where the man crosses the Suresnes Bridge. In the view the ⅛-in. steel tube with its cover of reinforcing bars alone is shown; the encasing concrete is yet to be placed.



REINFORCEMENT OF TWO REINFORCED CONCRETE SPECIALS ON PARIS PIPE LINE.

WOOD BLOCK PAVING on Market St., Philadelphia, seems to be assured after a long controversy. There appears to have been considerable rivalry between the advocates of different kinds of pavement, and after a contract for wood paving was awarded an injunction suit was brought to prevent the execution of the contract. This suit failed.

A SINGLE-PHASE MOTOR, with variable-speed and high starting-torque characteristics, has very recently been placed on the open market by the General Electric Co., of Schenectady, N. Y. This motor is of the type described in the papers of Messrs. F. Creedy, of Pittsburg, and E. F. W. Alexanderson, of Schenectady, before the recent convention of the American Institute of Electrical Engineers at Frontenac, N. Y., June 28. (Eng. News, July 8, p. 49.) The stator carries an imbedded winding much like an ordinary repulsion motor. The rotor is a direct-current armature with the usual commutator. While these machines have four field poles there are but two pairs of brushes. Each pair has its brushes 90° apart. The two pairs span quadrants, of the commutator, that are only 45° apart, giving an unsymmetrical appearance to the brush arrangement. A simple repulsion motor would have each pair short circuited, but in this design one pair is connected to an additional field winding in order to change the field magnetization. This arrangement alone gives over 300% of full-load torque at starting, with an equal increase of current over full-load value. A speed variation, down to 50% below synchronous, is made possible by a controller which inserts resistance or reactance between the normally short-circuited brushes and into the compensating-field circuit. This speed variation is accompanied by a corresponding decrease in horsepower developed. The power factor rises from 90% at no load to about 99% at full load and drops to 92% at 95% overload. The efficiency rises to some 81% at full load, but falls off to 68% at 95% overload. At present only ½, 1, 2, 3 and 5-HP. sizes are available.

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The League of American Municipalities held its annual convention last week at Montreal to discuss current problems in connection with city government. Enthusiastic friends of this society at its organization predicted for it a great field of usefulness in the promotion of reforms in methods of city administration. Others predicted that it would become merely an excuse for an annual "junketing tour" for certain city officials.

A report of the Montreal convention is printed elsewhere in this issue and it may be of interest here to present the impressions of the League's work and prospects which attendance at the convention gave to an impartial observer.

In the first place it is undeniable that the League as an organization is playing no very large part in municipal affairs. Of all the cities in the United States and Canada, fewer than 50 were represented at the convention and not all of these could be said to be effectively represented. Again, of the ten hours, more or less, during which the delegates were in session, a large percentage of the time was taken up with bombastic addresses "booming" different cities, with trivial discussions on unimportant matters and with the annual election and choice of a convention city, carried on like a political convention.

Looked at in this way the League as an organization is a disappointment to those who promoted it and hoped most from it, but we are not at all sure that this is the best or most correct point of view. When we compare the proceedings of the convention not with the ideal of what they ought to be, but with the way other conventions are carried on—conventions of railway officers, of commercial organizations, even of engineers—then the municipal officials do not show up so badly. There were at the Montreal meeting some really good papers on live subjects and much able and useful discussion. There was besides a keynote of devotion to the public interest, to the cultivation of efficiency in municipal work, to the elimination of politics and partisanship in municipal government. No public official could listen to and participate in the proceedings of the convention without a certain measure of benefit. And besides the formal sessions, it is true of this as every other gathering of men engaged in like occupations, that the informal discussions and conferences are often as instructive and beneficial as the convention sessions.

If then the League is not as influential for city betterment as its well-wishers could desire, it is yet doing a work of some usefulness and one which should be encouraged. It can probably do some things toward the betterment of our cities which the other two organizations devoted to municipal matters would be unable to do. Perhaps it may yet rise to the position of authority and influence which its original promoters hoped for.

The design of a forced-circulation, central, hot-water heating system is discussed elsewhere in this issue. While the method of design, rather briefly set forth in general terms, seems of particular use to the younger engineers, yet the article is worthy of further notice because of a method of attacking the problem in favorable contrast with some methods commonly used, whether these are logical or empirical.

It is recognized as good practice to select power-station machinery for continuous operation at its point of maximum efficiency—at "full load." This machinery is selected with the further requirement that it shall be able safely to carry additional loads for short intervals—the "peaks of overload"—at somewhat reduced efficiency. In contrast to this procedure, it is common enough in the design of heating plants to select the apparatus so that the plant can be run continuously at its greatest efficiency under the extremely severe weather conditions, as recorded or assumed, that may prevail for a few hours only. The heating plant then operates for the greater part of the time at light load and at decreased efficiency. It is never overloaded.

The author of the article mentioned arranges the design with the intention of forcing or overloading the heating system in severest weather and of running at full load with maximum efficiency during average cold weather. A younger designer needs additional warning, perhaps, that the final design in each case needs careful examination to see if it has the necessary overload capacity. The heat supply, necessary to maintain a high inside temperature, needs to be computed for some outside temperature a little below the lowest ever recorded for the locality. Then the ability to temporarily increase the flow of heating medium and the heat content of that medium needs examination to see if it be possible to supply the requisite heat to the buildings as needed.

Two years ago those sanitarians whose minds were still unsettled as to the danger of the spread of communicable diseases through air escaping from sewers or from plumbing systems, were disturbed by a report on the results of bacterial tests with sewer air made by Major Horrocks at Gibraltar. Outside of Great Britain, where the dangers from sewer air have always been grossly exaggerated, Major Horrocks' report made no very great stir; at the same time, it was sufficiently disconcerting to warrant a careful survey of the whole literature of bacteria and sewer air, and also to warrant further investigations of the subject. Such investigations, which in this country, at least, bid fair to be final, have been made by Prof. C.-E. A. Winslow, of the Sanitary Research Laboratory of the Massachusetts Institute of Technology. A critical summary of the literature of this whole subject, and also a summary of Prof. Winslow's conclusions based on both previous experiments and his own, will be found elsewhere in this issue. The matter which we reprint forms only a small part of an extensive pamphlet, which we commend to the consideration of any who wish to go further into the subject.

Prof. Winslow and the National Association of Plumbers, for whom the studies and pamphlet report were made, both deserve commendation for making available in convenient form a summary of all that has previously been done and written on the subject of sewer air and bacteria; they deserve even greater commendation for the important and convincing series of tests made by Prof. Winslow.

It seems unnecessary to attempt to add anything to Prof. Winslow's comments on the needlessness for much concern over the dissemination of disease germs by sewers and plumbing. We hope that his pamphlet will be widely circulated in Great Britain, and that the lessons which it teaches will be duly appreciated there. We are pleased to note that already the London "Surveyor" has expressed approval of Prof. Winslow's conclusions; it is only fair to the "Surveyor," however, to say that it has heretofore taken a rational stand on the spread of disease germs by sewer and plumbing air.

After all arguments based on reason and experience have failed, it sometimes happens that the added expense of filtering a water-supply will at last prevail on citizens and municipal authorities to put a stop to excessive waste by the introduction of meters. Years ago the commission under which the notable filtration investigations at Pittsburg were made recommended that meters be installed in order to reduce the excessive water consumption and waste in that city. Years passed and little or nothing was done to carry out this recommendation. We are pleased to see that the mayor of Pittsburg, according to the "Dispatch" of that city, has announced a plan "for decreasing the expenditure necessary to furnish the whole of Pittsburg with filtered water by installing meters and preventing waste." The annexation of Allegheny to Pittsburg has made waste-prevention measures all the more necessary in that great industrial city. Even without annexation the water consumption and waste in Pittsburg had increased to such an extent, by the time the filter plant was built, that it was scarcely equal to the task imposed upon it.

The experience of Philadelphia has been almost identical with that of Pittsburg, except that without the addition of any new territory the enormous filter plants there built were inadequate to meet the consumption and waste by the time they were completed.

The need of meters at Philadelphia in order to reduce the consumption to a reasonable figure was pointed out by the expert engineers who advised the installation of a filter plant. These experts showed how, with the consumption and waste reduced as might readily be done by meters, the first cost of a filter plant could be cut down by many millions of dollars. The obvious needs and advantages of meters were also most forcefully and strikingly shown by Mr. John C. Trautwine, Jr., Assoc. Am. Soc. C. E., during the earlier part of his incumbency of the office of Chief of the Bureau of Water. But so little did Mr. Trautwine's superiors, including the political bosses, relish the idea of doing anything that would diminish the magnitude of the filtration contracts, that Mr. Trautwine was summarily ordered to desist from further public utterances on the introduction of meters. Some references to these happenings were made in a communication to this journal from Mr. Trautwine published in our issue of Aug. 12, 1909. In that communication Mr. Trautwine pointed out the shrewd attempt now being made by the promoter of a lease of the Philadelphia water-works to use the local prejudice against meters to enable him to further his scheme for gaining possession of the water-works.

Other water bureau chiefs, before and since Mr. Trautwine's day, as well as the chiefs of the bureau of filtration, have advocated meters for Philadelphia. Within a few weeks Mr. Fred A. Dunlap, the present bureau chief, has recommended meters. It is reported that Mayor Reyburn has expressed himself as in sympathy with some movement towards meters, and that when the city councils reconvene in September an ordinance *permitting consumers to install meters at their own expense* will be introduced in the city legislature. If this is all that is seriously pro-

posed the introduction of meters at Philadelphia will be slow indeed. There is, however, vague talk about an "opening wedge," so perhaps more effective means of pushing meters and reducing waste will soon be brought forward.

It is a pity that it is not possible to show the citizens of both Pittsburg and Philadelphia the enormous sacrifice of life and health that has been caused by their blind refusal to introduce meters, cut down waste, and thus hasten the time when the whole population of each city could be given an adequate supply of pure water.

We trust that the mayor of Pittsburg will be successful in his advocacy of meters and we venture, somewhat faint-heartedly, to express the hope that the mayor and other officials of Philadelphia will soon see that it is their duty to make the same attempt.

State Board of Health Aid in Designing Sewage and Water-Purification Systems.

A special commission acting for the city of Trenton, N. J., appears to feel that that city has a grievance because the State Board of Health stated that it could not give the local body specific advice as to the best method of sewage treatment for Trenton. The State Board of Health is reported as having informed the local commission that the former was not an advisory body and that Trenton would have to work out the local sewage problem for itself. The local committee, in its report to the Trenton City Council,

> recommends a movement upon the part of the cities and other municipal corporations of this state, leading to such changes in the existing law as will compel the State Board to give cities and municipal corporations technical information regarding disposal of sewage and cost thereof, a method employed in other states, notably Massachusetts.

While it might perhaps be highly desirable for the New Jersey State Board of Health to be given sufficient power and funds to enable it to render more advice regarding methods of sewage disposal than it can now offer, we think it would be a mistake for the municipalities of New Jersey or any other state to become dependent upon their state boards of health for specific advice on methods of sewage disposal or on the best way of carrying out any other sanitary work. This does not mean that a state board of health should not give a considerable amount of general information to local authorities, or that it should not under some conditions criticize plans for sanitary works or methods of sanitary administration. What we do mean is that the function of a state board of health should be primarily one of supervision, general advice, and aid in such emergencies as epidemics, rather than that of a board of consulting and designing sanitary experts.

If a state board of health is to stand ready to give each and every community specific advice on sewerage, water-supply and like matters, then it would become necessary for it to turn itself into an immense state engineering, chemical and bacteriological bureau. This would require a large force of engineering and other employees and vast annual appropriations. Such a plan would meet with general disapproval; probably the quickest of all to resent its operations would be the municipalities themselves.

The local needs peculiar to each community must be studied in detail by men selected for the purpose and responsible to the authorities of the several communities. General principles may properly be laid down by the state board of health, and after specific plans have been worked out by or for local authorities they may very properly be submitted to the central authority for examination and test in accordance with the general principles just mentioned.

It should always be borne in mind that it is dangerous to lodge in a body that is intended to be supervisory, or one whose chief function is to see that other and minor bodies do their work properly, the power or duty of saying how the work shall be done. The minute the supervising body says how a sanitary defect, for instance, shall be remedied, then the supervising body becomes to a large extent responsible for the success or failure of the remedy. Thus the very object of supervision is defeated, since there no longer remains a supervising body.

To make our meaning clearer, let us revert to conditions as they actually exist in New Jersey to-day, as regards the prevention of stream pollution. The New Jersey State Board of Health, as successor of both the former State Sewerage Commission and the old State Board of Health, is charged with the responsibility of seeing that the municipalities of New Jersey do not injuriously pollute the waters of the state. Acting in accordance with express authorization, the State Sewerage Commission, and later the State Board of Health, issued orders to a number of municipalities requiring them to cease the pollution of certain waters within a specified date. If, now, the State Board of Health accedes to requests for specific information as to how that pollution shall be prevented, what would be its standing in court in case tests showed some years hence that the pollution had not been stopped? The municipalities would come into court and say that if the methods they had adopted for sewage disposal were not satisfactory, the responsibility was upon the State Board of Health and not upon them, because the local bodies had simply carried out the plans recommended by the State Board.

The parallel should not be drawn between the New Jersey and Massachusetts state boards of health in this matter. The Massachusetts board, years ago, was authorized by the Legislature to give advice to cities and towns in matters of water-supply and sewage disposal. The board has never been specifically authorized to order any and every municipality in the state, if in its judgment it saw fit, to stop the discharge of sewage into any stream or to provide works for purifying sewage. The Massachusetts board has acted almost wholly in an advisory character. It is true that its advice has been in effect mandatory in a majority of cases, but that is simply owing to the fact that the relations between the state and municipalities in Massachusetts, in matters of bond issues and public improvements, are altogether different from those obtaining in New Jersey. New Jersey municipalities are governed, in theory at least (and largely in practice), by general state laws, special legislation having been prohibited for many years by the State Constitution. In Massachusetts, the municipalities as a rule have to go to the Legislature whenever they wish to build or extend waterworks or sewers, provided new bond issues or new land- or water-takings are required. The Massachusetts legislative committee on water-supply and sewerage exercises a large measure of control over these legislative grants to localities, and it in turn is very largely guided by the advice that has been given to localities by the State Board of Health. That is to say, while there is no statutory requirement to that effect, common sense and the practical difficulties involved in having the Legislature control to so large an extent the details of municipal activities have compelled the legislative committee in charge of water-supply and sewerage to be guided by the advice and opinions of the State Board of Health. Consequently, if we understand the situation rightly, it is practically useless for a municipality to seek legislative authority for water-supply or sewerage construction until it has formulated its plans, laid them before the State Board of Health, and secured the approval of that body. Naturally enough, under such conditions the municipalities often go to the State Board of Health for advice and suggestions preliminary to attempting to formulate plans. Sometimes they make several such appeals in succession, as their own local investigation progresses. The detailed plans, however, are always worked out by the local authorities, and not by the State Board of Health.

It should be remembered that the Massachusetts practice outlined originated many years ago, when water and sewage purification, and means to prevent water pollution, were little-known subjects, particularly in this country.

No other state has gone so far as Massachusetts in the direction indicated. Many people think that state has gone too far, and that thereby its municipalities, and to a large extent its local engineers, are altogether too dependent upon the State Board of Health and too little upon their own technical resources.

Finally, we wish it to be understood that we are firm believers in the importance of central or state supervision of municipal activities; but we believe with equal firmness that so far as possible the powers and duties of the state central bodies should be wholly supervisory, departing from that only to the extent of giving such counsel and advice as would naturally come from the accumulated experience and also the possible superior technical ability of the experts at the command of a central body.

Masonry Arch Bridges of the World with Over 175-Ft. Span.

As far back as the end of the 14th century history records that some daring engineer threw across the river Adda, near Trezzo, Italy, an arch of stone masonry of about 250-ft. span. For about 40 years it remained, pointed out, no doubt, by the inhabitants of the district, as the ninth wonder of the world, but in 1416, one of the bands of marauders then engaged in interprovincial war razed it to the ground, leaving only the abutments, which are now standing. Had this bridge survived malicious assault and the test of time it would have stood over 500 years as the longest masonry arch in the world, for it was not until 1902 that the span was passed by the 277-ft. Luxembourg bridge.

In contrast to this long period of inactivity in the past, hardly a year now goes by that does not see the announcement of some record-breaking masonry span. The start of this construction was in the beginning of the 19th century, when the 200-ft. Grosvenor arch in England and the span at Turin, Italy, of similar length, were completed. These held the palm until 1864 when General Meigs completed his 220-ft. Cabin John Arch to carry the Washington (D. C.) Aqueduct. For nearly 40 years this grand span was not surpassed, until in 1902 the Luxembourg arch was finished, to be followed closely, in 1905, by the 295-ft. Plauen arch, the largest existing masonry arch in the world.

All of these arches are of stone masonry, but of late the concrete arch is challenging that of stone for record spans. The Gruenwald arch (1904) with 230-ft. span, the Walnut Lane (1908) with 233 ft., and the Sitter (1908) with 259 ft., are all among the first half-dozen in size, while Rocky River bridge at Cleveland, now in the course of construction, surpasses all three. To these should be added the Monroe St. arch at Spokane, Wash., a 281-ft. concrete span, described on another page of this issue, and just now being started. No list of masonry arches would be complete without some note of the monster Henry Hudson memorial arch bridge designed to cross Spuyten Duyvil Creek in New York City. This arch (Eng. News, Nov. 21, 1907, p. 539) is designed to have a 703 ft. clear span at the springing line, and is to be of concrete heavily reinforced with steel. Nothing definite is now known as to when this work will be started; at present it has not gone beyond the designing room.

Finally, it is reported that a 300-ft. concrete arch is to be built on the line of Larimer Ave., across Beechwood Boulevard in Pittsburg.

Mere size in an engineering structure is not always a valid claim for merit, but it is a distinguishing mark that carries interest. Therefore, for the purpose of record we have collected and print below a list of all the masonry arch bridges, with a clear span exceeding 175 ft., either of stone or of concrete, that are now in existence. So far as we know the list is complete, though we would be glad to hear of any omission we may have made.

By arbitrarily assuming a lower limit of 175 ft. in the table it is not intended to convey the idea that there are difficulties in building an arch of that size not to be expected in one of 150 or 160 ft. But the number of arches, particularly in Europe, with spans between 150 ft. and 175 ft., is

so large that the table would have been unwieldy had they been included.

The table has been subdivided into two classes, "stone" and "concrete," but the latter class also includes so-called reinforced-concrete bridges, though in arches of so long span steel is usually added to reduce compression stresses rather than to take tension, which latter is the true function of steel in reinforced concrete as at present defined. The arches of Sitter and Gruenwald each have a large amount of steel in the arch ring, and it is probable that the one on the Fogaras-Kronstadt line in Hungary has also, though our information on that point is meager.

It should be noted that the Luxembourg arch is credited with a 277.6-ft. span, but this distance is between face of abutments some 20 ft. below ground and the showing span is about 250 ft.

For comparison, the reader is referred to a similar table, containing a list of steel arch bridges exceeding 500 ft. in span, which we published in our issue of May 30, 1907, p. 583.

The list follows:

LIST OF MASONRY ARCHES OVER 175-FT. SPAN.

STONE.

Name.	Place.	Span, ft.
Plauen	Germany	295.3
Salcano	Austria	278.9
Luxembourg	Germany	277.6
Adda (New, 1903)	Italy	230.0
Cabin John	U. S. A.	220.0
Jaremcze	Austria	213.0
Gutach	Germany	210.0
Lavaur	France	201.8
Bogenhausen	Germany	201.7
Turin	Italy	200.0
Grosvenor	England	200.0
Gour Noir	France	196.8
Coppel	Germany	187.0
Vieille Brioude	France	183.7
Wiesen	Switzerland	180.4
Ballochmoyle	Scotland	180.0

CONCRETE.

Rocky River, Cleveland	U. S. A.	280.0
*Sitter	Switzerland	259.0
Walnut Lane, Philadelphia.	U. S. A.	233.0
*†Gruenwald	Germany	229.7
†Ulm	Germany	215.0
†Kempten	Bavaria	211.6
*Fogaras-Kronstadt	Hungary	197.0
Almendares	Cuba	190.0
†Lautrach	Bavaria	187.5
(Projected.)		
Henry Hudson	U. S. A.	403
Larimer Ave., Pittsburg, Pa.	U. S. A.	300
Monroe St., Spokane, Wash.	U. S. A.	281.0

*Reinforced concrete.
†Three-hinged arch.

LETTERS TO THE EDITOR.

Giving Percolating Sewage Filters Plenty of Air.

Sir: The article on "An Aerating and Flushing System for Percolating Sewage Filters," by William Gavin Taylor, M. Am. Soc. C. E., in your issue of Aug. 19, constitutes a strong American endorsement of the opinion expressed by me in your issue of May 6, that more air should be supplied to sewage filters than is usually done. The article will be greatly appreciated by those who recognize Mr. Taylor's able work in matters of sewage purification.

There is no doubt in my mind that some of the comparatively less satisfactory results from filters in this country than abroad are due partly to insufficient aeration. As our sewage is, generally speaking, about half as strong as European sewage, we should really be getting better results per million gallons with the same installations, or we should get the same results by giving filters much greater doses.

Very truly yours,
Rudolph Hering.

170 Broadway, New York City, Aug. 20, 1909.

Weak Timber Roof Arch Construction.

Sir: In Canada, where timber is still so cheap that steel building construction is making very slow progress outside of the principal cities, it is not uncommon to find halls, chiefly skating-rinks, of considerable size, built of wood. These are generally made with an arched roof of semi-circular ribs, covered with boards and tar or felt roofing. It occurs to me that a description of the construction and history of one of these buildings might be of interest to some of your readers.

The building in question was designed and built by a timber contractor who had erected similar buildings before, though not so large, and he evidently used the same construction as in his previous buildings. The size of the building was about 100 × 200 ft. and he made the arches of 1 × 6-in. boards nailed together, breaking joints. The boards were bent around a form on the ground, each arch consisting of nine layers of the 1-in. boards, and were then raised to position with block and tackle, having first been stiffened by two ⅝-in. wire ropes stretched horizontally at different heights from the base. The ribs were spaced about 6 ft. c. to c. and were held together, after being raised, by 1-in. boards nailed on the outside irregularly, leaving spaces of 10 or 12 ins. between boards.

The first thing that occurred to the writer while watching the construction of this building was that, although the wire ropes would undoubtedly be of assistance in carrying a snow load, there was nothing but the stiffness of the ribs themselves to resist wind pressure. This view was proved to be correct for, no sooner were all the ribs in place than a high wind, striking full on the side of the building, completely demolished it. An examination of the wreckage showed that nearly all of the arches were broken at a point about 30° from the vertical on the lee side.

In rebuilding, this experience was profited by to the extent that every second rib was stiffened by making it in Warren-truss shape, the top, or outer, chord consisting of six, and the bottom of four, 1 × 6-in. boards, with diagonals of the same material and ½-in. rods normal to the chords in every third or fourth panel. In addition, the wire ropes in the untrussed arches were laid diagonally, crossing in the middle. At this time, also, a gallery was added along each side, which was not contemplated in the original plans. In order to ease the public fears arising from the previous collapse the building was examined, and its safety certified to, by a government building inspector and a local architect and for a couple of years was used almost daily, often accommodating large crowds. However, last winter, after an unusually heavy fall of snow, the building one afternoon gave unmistakable signs of distress and, about an hour after being cleared of skaters, collapsed completely.

That there was not serious loss of life seems nothing short of providential and certainly building laws which allow such construction in buildings intended to accommodate large crowds of people deserve the severest condemnation.

Yours truly,
R. A. Wright.

Pottsville, Pa., Aug. 23, 1909.

The Need of Moral Training in Connection with Technical Education.

Sir: Mr. W. D. Taylor, Chief Engineer of the Chicago & Alton R. R., in his address to the Engineering Club of the University of Illinois (Eng. News, June 10, 1909), gives facts from that "chair of horse sense" which some one has recently suggested in connection with engineering education. Lately we have had considerable on this subject, as well as on the ethics of the profession and on the compensation of engineers, but the writer believes Mr. Taylor has struck the vital point of all these topics when he points out that the principal trouble with our scheme of technical education lies in its lack of moral training.

By all means, every engineering institution in America should adopt the honor system in conducting examinations; engineering students unable to maintain their integrity are unfitted for their life work, which so often consists in enforcing "square deals" in the business world. The "Specifications for a Good Engineer," written years ago by the late Major William Starling, hold good at this date, and will remain so, as they are of the sterling type. It is training that one needs to take away from college and not a mass of technical details. Will anyone deny that we need some well-trained men of morals in connection with the municipal engineering affairs of our American cities and towns?

The writer regrets to note that, in all the letters written to the editor on the question of the profession and its compensation, no one has seen fit to mention the substantial help and encouragement that young engineers so often receive at the hands of these "generals" or, let us say, the bulwarks of the profession. He feels that in no other line of endeavor is such assistance so freely given, but perhaps his own experience is an exceptional one. It must not be forgotten that some of these engineers are doing a great deal of unselfish work for the good of the profession. Engineering compensation is small because there are more first-class engineers than there are jobs and the relief for the dissatisfied is, evidently, finding some other kind of employment. The true reason for so many of us remaining in the business is that we like the work just as the "powder monkey" likes his. We want more engineers to attain the viewpoint shown in the late Geo. S. Morison's "The New Epoch."

A code of engineering ethics may be compared with our law against carrying concealed weapons: The man for whom it is intended is rarely affected thereby. Engineering in its finest sense is a gentleman's calling and we need more golden rule and less printed resolutions in its practice. Will the code put an end to this pernicious friction among some of our well-known men? No, because we will never legislate human nature out of existence.

These ideas are written from the standpoint of an engineer of some ten years' experience in various parts of the United States and Latin America and who happens to have had training in that "institution on the banks of the Mississippi." Very respectfully,

Stanley A. Miller, Assoc. M. Am. Soc. C. E.
Director, Irrigación de Azua, Republica Dominicana, W. I.

A Reply to the Criticism of the Burley Type of Lock.

Sir: In response to the criticisms of Lieut.-Col. C. McD. Townsend upon my lock design as outlined in the article "A Suggestion of a Type of Lock for the Government Canal at Sault Ste. Marie," Engineering News, June 24, 1909, p. 683, I submit the following, arranged under the specific criticisms:

BALANCED PRESSURES.—While the gates are spoken of as balanced they are really out of balance to the extent of nearly the strength of the opening cables. Thus when receiving their load the tendency is to close and that tendency increases as the load is applied. They cannot open unless pulled open.

WATER RAM EFFECTS.—Water ram effects can be had only from water ram, which cannot occur except in a closed system. Therefore water ram effects will not occur and so no cables would be broken by it. They could only break when gates are being operated and then without dangerous result.

SIDE FILLING CULVERTS.—The probability of one filling-valve opening without the other is so remote that I would say that to consider it would be traveling into the realm of foolish precaution.

DISCHARGE AGAINST VESSEL.—10,000 cu. ft. of water or any other amount cannot be discharged against the side of a vessel, since the water flows several feet below her keel, and is distributed the whole length of the lock chamber.

EXPENDITURE OF FORCE.—When comparison of the power required to operate six valves in the Poe Lock with that required to operate two in the proposed lock is made, it would be found in practice that not much difference existed. The load carried by the two valves in the proposed lock, I will admit, is 20 times greater than that carried by one valve in the Poe, but that is an unfair comparison. The two valves should be compared with six in the Poe, then it will be found that a difference of load of less than four to one exists in the respective locks, and no where near that much difference in power is required.

ARRANGEMENTS OF PORTS.—Graded ports to fill the lock uniformly from one end to the other so as to eliminate surging are one of the most vital essentials in lock building. Why Col. Townsend considers them unnecessary I cannot understand.

FILLING FROM FORE-BAY.—The disadvantages of a fore-bay would be zero if a lock of this type was constructed, for a fourth lock would never be needed to lock through all the boats as fast as safe navigation of St. Mary's River will permit.

GREATER COST AT GREATER DEPTH.—Greater depth of chamber will not entail greater cost as it can be obtained without excavation by eliminating the lock floor of the Poe lock.

EXCESSIVE CLEARANCE.—Experience has taught vessel men that a loaded boat cannot move with reasonable speed and hold steerage way unless there is at least 10 ft. of water under her.

LENGTH.—A lock 850 ft. long will not lock as many boats through at one time as one 1,350 ft., but it will lock four times as many in a given time.

Respectfully,
Geo. A. Burley.

Crystal Falls, Mich., Aug 16, 1909

THE LATEST NOVELTY IN WATER FILTRATION is set forth in the "Item" of Lynn, Mass., for Aug. 21, in the course of a report on the scheme of water filtration submitted to the authorities of that city. We quote as follows:

> The system of the municipal filtration company is one of units which operate by upward percolation; downward sedimentation; self-cleansing with its own purified water and the elimination of the possible contamination by seepage.
>
> In the units the raw water is received in a covered container of reinforced concrete and by static pressure is forced through the inner chamber, the shell of which is also of reinforced concrete.
>
> First is met a bed of slats, set at an angle of 45°, this bed having a triple function: The support of the purifying bed, the regulation of the upward percolation of the water, the elimination of the heavier organic and sedimentary matters.
>
> On this slat bed is fastened a heavy mesh of galvanized wire netting, on which rests a stratum of screened charcoal. This is covered by a fine mesh of copper wire. The action of this electrolytic combination assists in maintaining the aerobic conditions necessary to the elimination of bacteria.
>
> Resting on this copper wire is a heavy stratum of perfect spheroids of pure silica through which the water finally comes devoid of color, taste, odor, sediment and pathogenic organisms.

The Design of Members Subjected to Combined Stresses.

By E. L. HANCOCK.*

During the past four years the writer has conducted tests of steel under combined stresses. These have been carried out in such a way as to combine torsion with tension, flexure and compression. It is the writer's purpose in this brief report to make a summary of these tests, as well as other tests that have been made along the same lines, and to present these results in such form that they may be readily available for the purposes of the engineer.

Among designers of structures subjected to combined stresses three theories have been used, namely:

1. THE MAXIMUM-STRESS THEORY.—This theory assumes that the material yields when the resultant tensile or compressive stress on any element reaches a certain maximum. For calculations under this theory, the combined or resultant stress in a member or test-piece is to be calculated by the following formula:

$$q = \tfrac{1}{2}\left(p \pm \sqrt{p^2 + 4\,p_s^2}\right) \quad \ldots\ldots (1)$$

where

q = maximum stress-intensity in the material at any given point.

p = tension or compression unit-stress at this point.

p_s = shearing unit-stress at this point.

The values p and p_s have their ordinary meanings. The theory asserts that when this resultant stress q reaches a fixed maximum Q, representing the yield-point of that material, then the piece yields.

2. THE MAXIMUM-STRESS THEORY.—This theory holds that the material yields when the longitudinal *deformation* of any element reaches a certain limit. To use the theory for calculating the resultant strain from the simple stresses, Poisson's ratio of lateral contraction to longitudinal extension must be known. The ratio is ordinarily taken as 0.25. Using this value, the resultant stress would be given by the following formula:

$$q = \tfrac{3}{8}\,p \pm \tfrac{5}{8}\sqrt{p^2 + 4\,p_s^2} \quad \ldots\ldots (2)$$

where the same meaning is to be attached to the symbols as above.

Tests give the values of Poisson's ratio as follows:

Steel, hard	0.295
Steel, soft	0.299
Iron	0.277
Brass	0.357

It is seen that these values differ considerably from the value 0.25, so that formula (2) can hardly be expected to furnish correct results. This formula is in use to a considerable extent in Europe.

3. THE MAXIMUM-SHEAR THEORY.—The third theory, which is but little used, assumes that the material yields when the greatest *resultant shear* on any element of the piece reaches a certain limit. The resultant shear is computed from the simple (ordinary) stresses by the following formula:

$$q_s = \tfrac{1}{2}\sqrt{p^2 + 4\,p_s^2} \quad \ldots\ldots (3)$$

and yielding takes place when q_s reaches the shearing yield-point Q_s of the material.

It will be shown that this formula fits the results of tests of material subjected to combined stresses much more exactly than either of the others.

For designing shafts and other members subjected to combined torsion and bending, the equivalent bending moment is usually found from formula (1) by multiplying through by $\frac{\pi r^3}{4}$ where r is the radius of the shaft. The equation may then be written:

$$M_e = \tfrac{1}{2}\left(M + \sqrt{M^2 + T^2}\right) \quad \ldots\ldots (4)$$

where M_e is the equivalent bending moment, M the greatest bending moment due to transverse loads on the shaft and T the twisting moment.

The use of equation (2) in similar manner gives an equivalent bending moment

$$M_e = \tfrac{5}{8}\,M + \tfrac{3}{8}\sqrt{M^2 + T^2} \quad \ldots\ldots (5)$$

Formula (1) is also improperly used to get the so-called equivalent twisting moment by multiplying through by $\frac{\pi r^3}{2}$ and at the same time interpreting q as a unit shearing stress. This results in the familiar formula:

$$T_e = M + \sqrt{M^2 + T^2} \quad \ldots\ldots (6)$$

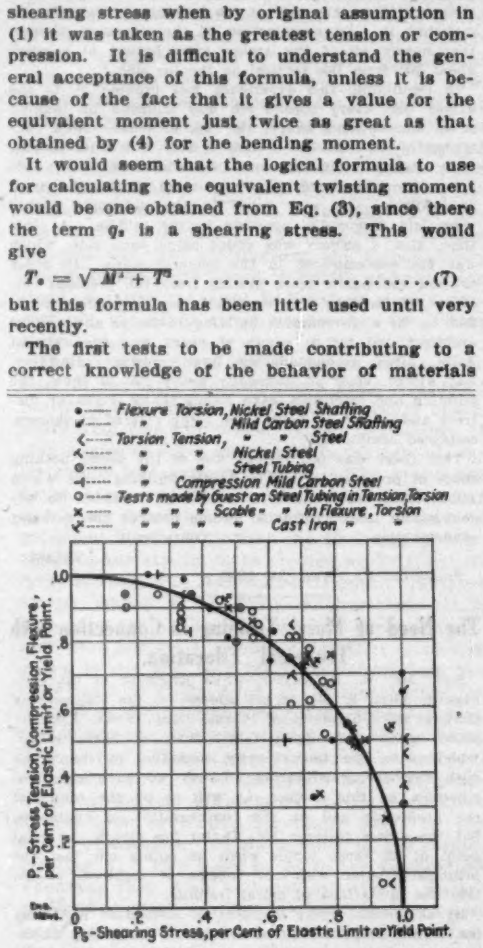
where T_e is the equivalent twisting moment. This formula is illogical, to say the least, since in its derivation it is necessary to use q as a shearing stress when by original assumption in (1) it was taken as the greatest tension or compression. It is difficult to understand the general acceptance of this formula, unless it is because of the fact that it gives a value for the equivalent moment just twice as great as that obtained by (4) for the bending moment.

It would seem that the logical formula to use for calculating the equivalent twisting moment would be one obtained from Eq. (3), since there the term q_s is a shearing stress. This would give

$$T_e = \sqrt{M^2 + T^2} \quad \ldots\ldots (7)$$

but this formula has been little used until very recently.

The first tests to be made contributing to a correct knowledge of the behavior of materials subjected to combined stresses were made by Mr. J. J. Guest (Physical Society of London, Sept., 1900). The writer has made tests during the past four or five years (Am. Soc. Testing Materials, 1905, 1906, 1907 and 1908), and tests have also been made by Mr. W. A. Scoble (Phil. Mag., Dec., 1906), and Mr. Turner (Engineering, Feb. 5, 1909). These tests were made to study the effect on the strength, say tension or compression, due to an applied shearing stress, or vice-versa.


Flexure Torsion, Nickel Steel Shafting
" " Mild Carbon Steel Shafting
Torsion Tension, " " Steel
" " Nickel Steel
" " Steel Tubing
" Compression Mild Carbon Steel
Tests made by Guest on Steel Tubing in Tension, Torsion
" " Scoble " " in Flexure, Torsion
" " " " Cast Iron " "
P - Stress Tension, Compression, Flexure, per Cent of Elastic Limit or Yield Point.
Ps - Shearing Stress, per Cent of Elastic Limit or Yield Point.
0
.2
.4
.6
.8
1.0

Curve shown is a circular quadrant corresponding to the equation

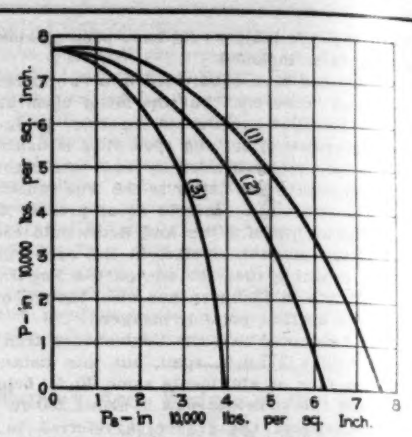
$$\left(\frac{p_s}{P_s}\right)^2 + \left(\frac{p}{P}\right)^2 = 1$$

where p and p_s are the tensile (or compression) and shearing stresses at failure under combined loading, and P and P_s are the elastic limits in tension (or compression) and shear, respectively.

Fig. 1. Results of Recent Tests of Materials Under Combined Stresses.

The results of all these tests are brought together in the diagram Fig. 1 herewith. Abscissas in this diagram represent the shearing stress (ordinary) developed by the torsional moment at the failure load, in per cent. of the elastic limit in shear. The ordinates represent the ordinary tensile or compressive stress (or the extreme-fiber stress in bending) at failure under combined loading, in per cent. of the tensile or compressive elastic limit.

It will be seen that the points are grouped very closely around the circular curve connecting 100% on the X and Y axes, drawn in the diagram. Putting this curve into the shape of a formula, and using the symbols:



Abscissas represent shearing stress } in lbs. per sq. in. at
Ordinates represent tensile or compression stress. } failure under combined loading.

The curves represent the formulas

(1) Maximum-Stress Theory,

$$q = \frac{1}{2}\left(p + \sqrt{p^2 + 4\,p_s^2}\right)$$

(2) Maximum-Strain Theory,

$$q = \frac{3}{8}\,p + \frac{5}{8}\sqrt{p^2 + 4\,p_s^2}$$

(3) Experimental Result (curve of Fig. 1).

$$q = \sqrt{p^2 + \frac{b^2}{a^2}\,p_s^2}$$

Fig. 2. Ultimate-Strength Curves for Combined Loading, According to Three Different Theories.

p = tension or compression at failure under combined loading,

b = elastic limit in tension or compression,

p_s = shearing stress at failure under combined loading,

a = elastic limit in shear,

all in pounds per square inch, we get the formula

$$\left(\frac{p}{b}\right)^2 + \left(\frac{p_s}{a}\right)^2 = 1$$

or

$$p^2 + \frac{b^2}{a^2}\,p_s^2 = \text{a constant for the material} \quad \ldots\ldots (8)$$

which has the form of formula (3), corresponding to the maximum-shear theory.

Knowing b and a from the results of tests of the material in simple tension and simple torsion respectively, and having given either p or p_s in any special problem, the other simple stress may be determined by using formula (8).

The equivalent twisting moment for a shaft subjected to combined bending and twisting, derived from (8), is given by the relation

$$T_e^2 = T^2 + \frac{4a^2}{b^2}\,M^2 \quad \ldots\ldots (9)$$

If the elastic limit in shear is taken as one-half the elastic limit in tension (9) becomes

$$T_e^2 = T^2 + M^2 \quad \ldots\ldots (10)$$

which is the same as (7), the formula derived by considering the maximum shear theory to hold. This assumption that a equals one-half of b is hardly borne out by the results of tests that have been made, as is shown by Table I.

An attempt has been made in Fig. 2 to show the difference in the shearing strength given by the formulas representing theories (1), (2) and (3) and expressed in equations (1), (2) and (8). The material under consideration had an elastic limit in tension of 76,000 lbs. per sq. in.

TABLE I.

Material.	b Fiber stress at elastic limit, tension, lbs. per sq. in.	a Fiber stress at elastic limit in shear, lbs. per sq. in.	$a \gtrless \frac{b}{2}$	Value of $\frac{4a^2}{b^2}$
Steel tubing.....	21,000	10,500	=	1.00
Nickel steel.....	76,500	38,000	<	.98
Carbon steel.....	47,000	30,400	>	1.66
Carbon steel.....	35,500	24,400	>	1.84
Rivet steel.....	38,900	25,400	>	1.44
Nickel steel.....	56,000	36,000	>	1.66
Steel tubing.....	17,000	11,500	>	1.82
Steel tubing.....	28,000	16,000	>	1.30
Steel tubing.....	20,000	12,000	>	1.44
Steel shafting...	35,120	22,300	>	1.61

*Assistant Professor of Applied Mechanics, Purdue University, Lafayette, Ind.

TABLE II.

T	M	M_e Equation 4.	T_e Equation 5.	M_e Equation 6.	T_e Equation 7.	T_e Equation 9.
10	10	12.07	12.55	24.14	14.14	16.31
"	20	21.17	21.45	42.34	22.34	27.64
"	30	30.81	31.00	61.62	31.62	39.80
"	40	40.61	40.75	81.22	41.22	52.40
"	50	50.00	50.80	100.80	50.80	65.20
20	10	16.18	17.70	32.36	22.36	23.80
"	20	24.15	26.60	48.30	28.30	32.60
"	30	33.02	33.80	66.04	36.04	43.50
"	40	42.36	42.90	84.72	44.72	55.20
"	50	51.90	52.35	103.80	53.80	67.40
30	10	20.82	23.50	41.64	31.64	32.60
"	20	28.33	30.40	56.66	36.66	39.50
"	30	36.21	37.76	72.42	42.42	48.90
"	40	45.00	46.25	90.00	50.00	59.60
"	50	54.15	55.15	108.30	58.30	71.00
40	10	25.61	29.50	51.22	41.22	42 02
"	20	32.36	35.45	64.72	44.72	47.60
"	30	40.00	42.80	80.00	50.00	55.60
"	40	48.28	50.35	96.56	56.56	65.20
"	50	57.01	58.75	114.02	64.02	75.80
50	10	30.49	35.60	60.98	50.98	51.60
"	20	36.92	41.15	73.84	53.84	56 20
"	30	44.15	47.65	88.30	58.30	63.20
"	40	52.01	55.01	104.02	64.02	71.80
"	50	60.35	62.90	120.70	70.70	81.50

Equation (8), the equation of the curve in Fig. 1 and of curve 3 in Fig. 2, gives the proper elastic limit in shear, while (1) and (2) give an elastic limit too large. Nearly all values in shear given by (1) and (2) are larger than those obtained from tests, and particularly when the tensile stress is small, p_s comes out much too large. When p is zero, curve 1 gives p_s = 76,000, curve 2 gives 62,000, and curve 3 gives 38,000. The shearing strength of the material in question is only 38,000, so that the use of curves

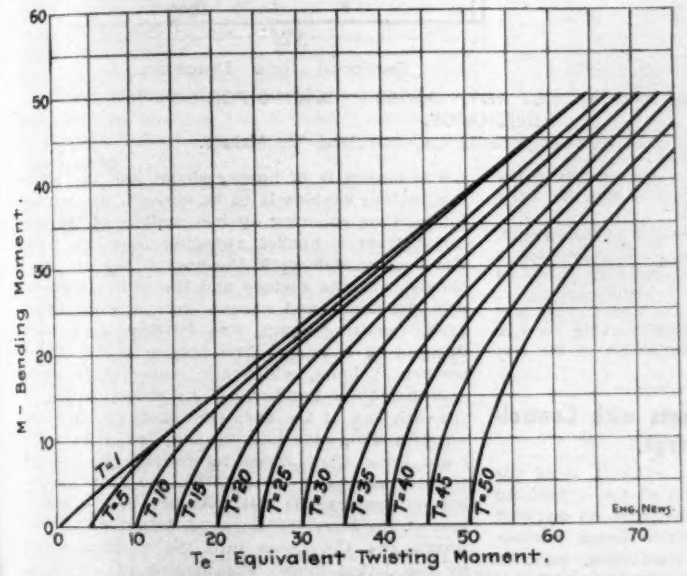


FIG. 3. DIAGRAM OF EQUIVALENT TWISTING MOMENTS FOR DESIGNING SHAFTS FOR COMBINED BENDING AND TORSION.

Ordinates are bending moments.
Abscissas read equivalent twisting moment for simple twisting moments from 5 to 50 as marked on the curves.
Diagram represents formula

$$T_e^2 = T^2 + \frac{4a^2}{b^2} M^2$$

where T_e = equivalent twisting moment,
T = actual torsional moment,
M = actual bending moment,
$\frac{4a^2}{b^2} = 1.66$, as shown by tests of Table I.

To use diagram, select curve corresponding to the known torsional moment, follow along curve to ordinate marking the known bending moment, and follow vertically down to base-line to read equivalent twisting moment.

1 or 2 in such cases at least will lead to unsafe design.

Table II has been arranged to show the values given the equivalent bending and twisting moments for various values of T and M. The inchton has been used in working out the values and $4a^2/b^2$ has been taken as 1.66, this being the approximate value for mild steel as shown by the tests reported in Table I. It is seen that equation (6) always gives a higher bending moment than equation (4) and that the equation (9) gives values between those given by equations (5) and (7). It is believed that those given by (9) are entirely safe and inasmuch as all experiments point to the truth of this equation, these values are recommended for use. For convenience of design the values given by (9) are shown graphically in Fig. 3.

In conclusion it may be said that the maximum shear theory agrees more nearly with the results of tests than any other and the resulting formula or some modification of it should be used in practice. The following formulas are recommended:

$$q_s^2 = p^2 + \frac{b^2}{a^2} p^2_s,$$

$$T_e^2 = T^2 + \frac{4a^2}{b^2} M^2.$$

It also merits notice that in giving their results in terms of the elastic limits of simple shear and simple tension, Guest and Scoble used the yield-points, while Turner and the writer used the limits of proportionality. The results plotted in Fig. 1 are, therefore, in part on one basis and in part on the other. But an examination of Fig. 1 shows no perceptible difference in the outcome. The convenience of locating the yield-point is an advantage in its favor, and it follows that the constants a and b in the formulas may be taken at the yield-points without error.

The Testing of Galvanized and Other Zinc-Coated Metals.*

By WM. H. WALKER.†

For many years the only commercial method of coating iron with zinc was the "hot-galvanizing" process in which the iron (or steel) article was simply dipped into a bath of molten zinc. "Galvanized-iron," the name applied to this product, is a misnomer, as no galvanic action occurs.

Within the last ten years the "wet" or "cold-galvanizing" process has appeared in which metallic zinc is deposited upon an iron plate from an aqueous solution of a suitable zinc salt by means of an electric current. Recently a third process has come into use in which the iron article is heated in a closed chamber in the presence of fine divided metallic zinc and zinc oxide. The product has been named from its discoverer, Sherard Cowper-Cowles, of England, "sherardized iron."

LIMITATIONS OF THE PRESENT TEST.—Although there is a marked difference in appearance and in structure between these three kinds of zinc-coated iron, only one method of testing them has been used, namely, the "Preece" or copper-sulphate immersion test.

As standardized by the American Telegraph & Telephone Co., this test is essentially as follows: A standard solution of copper sulphate is prepared by agitating a nearly saturated solution of this salt with copper oxide until it is perfectly neutral. It is then diluted to 1.186 sp. gr. at 65° F. When a rod of zinc and one of iron are placed in this solution, the metals pass into solution as soluble sulphates, an equivalent weight of copper being at the same time deposited on the metallic rods. The copper deposited on the zinc surface is black, spongy and easily removed, while on the iron it is dense and of a bright color.

When this reaction is used in testing galvanized iron, it is assumed that the speed of solution of the zinc is a direct function of the time of immersion, and by the number of one-minute immersions necessary to dissolve the zinc from the iron and to deposit a film of bright copper thereon, the thickness of the zinc can be estimated. It will be seen that this method measures the thickness of the coating only at its thinnest point, and that the assumption is made that no bright copper will be formed until the iron base is reached. To appreciate the limitations of this test it is but necessary to note the structure of the three classes of zinc-coated iron.

A polished oblique section of ordinary hot-galvanized iron etched with iodine reveals three distinct layers. First a coating of zinc, which varies in thickness in accordance with the temperature of the zinc and the amount of squeezing or wiping applied to the article before the zinc solidifies; second, a distinct layer of a zinc-iron alloy, termed Alloy B, which varies in thickness with the temperature of the zinc bath and the length of time the iron was subjected to it; third, the iron base itself. Between the zinc and Alloy B there is generally a second alloy, Alloy A, which is a thin, discontinuous layer, richer in zinc than Alloy B; and between the iron and Alloy B is a third alloy relatively unimportant, which is very rich in iron, Alloy C.

The structure of wet-galvanized iron is comparatively simple, the layer being practically pure zinc.

Sherardized iron, on the other hand, presents a relatively complex structure. The metallic zinc penetrates the iron, forming deep layers of the alloys B and C, and in place of Alloy A there occurs a number of compounds, as yet unidentified. Upon the surface there is generally a layer of relatively pure zinc, although frequently the process is carried to the point where only a deep layer of alloys is formed. When examined under the microscope this alloy is seen to be covered with deep cracks or fissures as though the alloy in forming had contracted. It is thus apparent that in testing galvanized iron made by these different processes we are dealing with three very different materials.

TEST FOR DURABILITY OR RESISTANCE TO CORROSION.—It is the purpose of this paper to treat of zinc-coated iron with regard only to its durability or resistance to corrosion, and not to its tensile strength. From this standpoint a test should, if possible, indicate the following:

(1) The uniformity and thickness of the zinc coating; (2) the continuity of the coating with reference to pin holes; (3) the purity of the zinc, and (4) the toughness and ductility of the coating

The corrosion of pure zinc in water is very slow. If, however, the zinc is in electrical contact with any material upon which the hydrogen can be liberated, the corrosion of the zinc is relatively rapid. The iron-zinc Alloy B, and iron itself, are both surfaces on which this depolarization action can take place, and hence so long as neither the iron nor the alloy is exposed, other things being equal, the zinc coating will not corrode. The importance, therefore, of maintaining a uniform coating of metallic zinc upon the iron can be appreciated.

To determine whether the ratio of the time of immersion required to produce a bright copper surface was in reality a measure of the thickness of the zinc coating, samples of galvanized sheets were obtained and tested. The weight of zinc per square inch area was determined by dissolving the zinc from the sheets without attacking the iron-zinc alloy. This can readily be accomplished by heating the galvanized sample together with a piece of metallic iron in boiling caustic soda until the generation of the hydrogen ceases. As might be expected, the ratio between the time of immersion required to show the presence of bright adherent copper and the amount of zinc present per unit area, depends upon the uniformity with which the coating of zinc is spread upon the iron base. In the case of 14 pieces of galvanized sheet iron, for example, the average ratio found was 23, while the greatest variation in either direction was but 20. This test, therefore, so far as indicating the uniformity of the coating and measuring the thickness of the zinc are concerned, is fairly satisfactory; but Alloy B is always indicated as iron, and hence, when the test is applied to Sherardized articles, very erroneous and misleading results may be obtained.

The presence of the channels or pin holes caused by the free iron surface coming in contact with the zinc and causing it to pass into solution cannot be detected by the copper-sulphate method as these pin holes down through the zinc to the iron fill up with black, spongy copper and cover up the bright copper spot at the bottom.

The purity of the zinc cannot be determined as the bright copper particles precipitated by this method are so small that they are lost in the mass of black, spongy copper.

Finally, the fourth factor, the toughness or the ductility of the coating, cannot be determined due to the same tendency of the spongy copper to cover up the bright copper deposits, which indicate cracks extending down through the zinc coating to the alloy or iron underneath.

Method for Detecting Pin Holes and Cracks.

The relation between the presence of pin holes in the zinc surface and cracks due to a brittle coating, and the durability of the structure as a whole has heretofore been studied, largely because no method of detecting these imperfections has been available. The following phenomenon serves as a basis for such a test. If a piece of zinc be placed in a strong solution of caustic soda heated to about 100 C., no action is noticeable. If now the zinc be touched with a piece of iron, hydrogen is liberated in great volume from the iron. Small cracks in the zinc coating may be easily detected in the same way.

Ordinary hot-galvanized ware is generally very free

*Condensed from a paper read before the American Society for Testing Materials, at Atlantic City, N. J., June 28-July 3, 1909.

†Professor of Industrial Chemistry, Massachusetts Institute of Technology.

from imperfections of this kind, while wet-galvanized ware, on the other hand, is frequently very porous, generating hydrogen at numberless small points over its entire surface. Theoretically, the best electroplated surface should be that carrying the greatest weight of zinc per unit area, deposited at the slowest rate. That is, the lower the current density at the cathode in plating, the less porous will be the deposited metal, and the thicker this dense deposit is, the better protection will it be. A great many tests on electroplated zinc-coated iron were made, the samples varying in both these particulars. In every case those deposited most rapidly were the most porous, and the results showed that the time of plating was more important than the weight of zinc per unit area, although there was a minimum below which it was not safe to go.

Method for Measuring the Combined Effect of Imperfections.

As the rapidity of hydrogen generation from zinc is a function of the presence of an alloy of zinc and iron, hence the more impure the zinc coating, the more impure will be its solution in acid. Accordingly the impurity of the zinc, the presence of pin holes and cracks and the thinness of coating are all factors which act in an accumulative way to increase the rate at which hydrogen is generated when the zinc surface is exposed to acid. This method has been developed by Mr. Charles L. Campbell, in his thesis for the B. S. degree at the Mass. Inst. of Technology, and found to give very concordant results. The apparatus employed may take any convenient form, it being but necessary to expose a known area of the zinc coating to a standard acid solution under uniform conditions and to measure the hydrogen generated per minute. In almost every case a sharp maximum is reached giving the resultant of all the different factors which make for rapid dissolution of the zinc. Thus in a series of wet-galvanized sheets, those electroplated for 15 minutes reached a maximum of 7 cu. cm. in three minutes; those plated for 30 minutes a maximum of 14 cu. cm. in 10 minutes, while those plated for 45 minutes showed a rather poor maximum of 6 cu. cm. in 30 minutes. In many samples of Sherardized product there were two maxima on the curve showing the amount of hydrogen generated per minute. This indicates that there is first an action between the outside zinc coating and the iron-zinc alloy, and later a well defined action between the alloy and the iron.

Service tests with galvanized iron are of necessity very slow at best, and the relation of the above phenomenon to the real durability of the material can be determined only after a number of years. Something can, however, be learned by the study of ware which has already been exposed for sufficient time to determine its durability. Most of the material available for the purpose was in the form of fence wire; from a study of these the following conclusions are drawn:

1. Thickness of coating.—In every instance where a very durable fence was found, the coating of zinc proved to be relatively very thick. On the other hand, the wire fences which showed marked corrosion in from one to two years proved to have almost no zinc on the iron, the zinc color being due to a layer of alloy alone. It is doubtless true that the purity of the iron used in the wire itself plays an important part in determining the ultimate durability of a fence, yet in the opinion of the writer the thickness of the zinc coating calls for more immediate attention. The modern method of close mechanical wiping the wire as it emerges from the zinc bath, produces too often a wire covered not with zinc, but only a thin layer of electro-negative iron-zinc alloy, which affords but little protection to the iron. To produce a wire with a liberal coating of zinc would, of course, cost more both on account of the extra zinc and on account of a somewhat smaller production per machine.

2. Purity of Zinc.—It is probably a necessary consequence of hot galvanizing that the zinc becomes somewhat contaminated with dissolved iron. It is apparent that this should be kept at a minimum in order that the coating should be of maximum durability.

3. Flexibility of the Zinc Coating.—The important objection to placing a thick coating of zinc upon wire used for fencing is that such a coating cracks off when running through the machines. This objection applies only to those wires which are subjected to very sharp bends or turns. It is possible that by passing the zinc-coated wire through dies or under grooved rolls that the crystalline condition of the zinc could be destroyed and the flexibility and ductility materially increased.

Summary.

It has been shown:

1. That the copper-sulphate immersion test is of value in determining the uniformity of coating and relatively the thickness of coating in hot and in wet-galvanized products; but that it is worthless in the case of Sherardized products, and gives no idea of other important factors involved in the durability of the structure.

2. That by immersing a galvanized product in hot, strong caustic soda, the presence of any unprotected iron may be easily detected, however small such area may be.

3. That the weight of zinc per unit area apart from the zinc-iron alloy may be analytically determined by dissolving the zinc from the plate through treatment with hot caustic soda while in contact with metallic iron.

4. That theoretically the rate at which hydrogen is evolved when the galvanized product is immersed in dilute acid, should indicate its relative durability; that inferior products should reach a maximum in a few minutes compared with a much longer time for better products.

5. That in the very important matter of fencing wire, while the purity of the iron used is of consequence, a more immediate necessity is a heavier coating of zinc on the wire.

6. That the flexibility of a zinc-coated wire may possibly be increased by mechanically working the wire in rolls or dies to destroy crystallization in the zinc coating.

Concrete Depositing Buckets with Controllable Discharge.

In many kinds of concrete work it is of advantage to have close control of the depositing of the concrete in place, in order to prevent undue strains in high and narrow forms, to allow of careful tamping around reinforcing bars, to allow of placing small quantities at different points, or to enable the concrete to be spread in a broad thin sheet. Many of the numerous forms of concrete dumping buckets now in use discharge their contents in a mass, while some enable the discharge to be regulated as required. Some buckets of this latter class have been described in our issues of July 25, 1907, and March 26, 1908, and a recent design is shown in the accompanying cut.

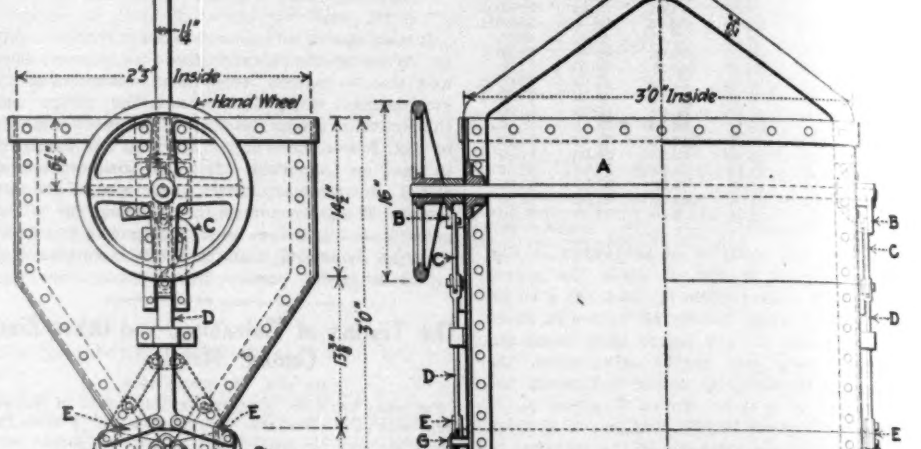


FIG. 1. CONCRETE DEPOSITING BUCKET WITH DOORS PROVIDING FOR CONTROL OF THE DISCHARGE.

The Ohio Ceramic Engineering Co., Cleveland, O., Makers.

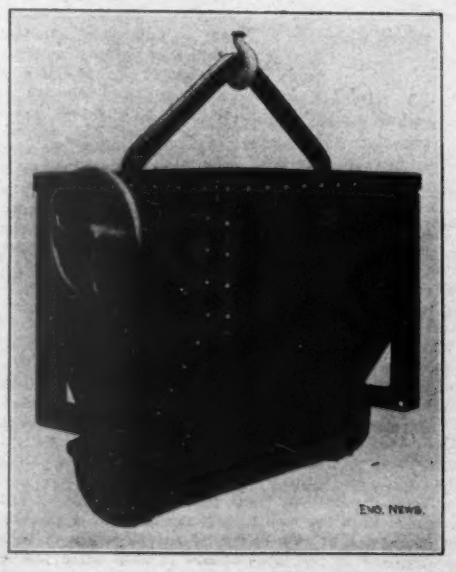


Fig. 2. Concrete Depositing Bucket with Controllable Discharge and Fitted with Supporting Brackets.

The bucket is of hopper shape, and the tapering bottom enables it to be entered into narrow forms, thus ensuring against spilling of the material from a bucket swinging over the form. For floor or slab work, the bucket may be moved slowly over the surface and the concrete gradually deposited and spread over a considerable area, requiring much less leveling than when dropped in a heap. The bottom is formed by segmental doors, which are connected to levers operated by a hand-wheel, as shown in Fig. 1. On each end of the operating shaft (A) is keyed an arm (B), attached by the link (C) to the main lever (D). Short levers (E) (E) connect this to the two doors (F) (F), the doors revolving on centers (G) (G). As the hand-wheel is turned, the lever (D) is raised, bringing the short levers and the doors into the position shown by the dotted lines. For buckets of over 1 cu. yd. capacity, the hand-wheel operates the shaft by gearing, in order to give greater power. The doors were made originally of steel plate, but are now made of cast iron, thus dispensing with the riveted work.

The special advantage claimed for this bucket is that the flow of concrete is under complete control. The doors can be opened to any desired width, and will remain in that position, and they can be closed while the concrete is flowing. When closed, they are past the centers, and are in such position that the weight of the contents of the bucket tends to hold them closed rather than to open them. For narrow forms the bucket is placed, of course, lengthwise with the form, and may be moved along as the concrete flows. For slab work, however, it is placed with its greater length crosswise of the area to be covered. The bucket is emptied rapidly when the doors are opened wide, as in cases where it is not necessary to control the discharge.

For railway and bridge construction work, the buckets are transferred usually on flat cars from the mixer to the place where the concrete is needed, and are there handled by a derrick. In some cases, however, they are used in connection with cableways. Fig. 2 shows the bucket fitted with standards or brackets, this arrangement being used where the buckets have to be transported on flat cars but are required also to enter narrow forms. A pair of timbers placed

on horses on the floor of the car serves to support the bucket. Where it is not necessary to set the bucket in the forms, it may be fitted with vertical legs which extend below the level of the bottom and are riveted to a horizontal rectangular frame, so that the bucket is entirely self-supporting.

This type is known as the "Ideal" bucket, and is manufactured by the Ohio Ceramic Engineering Co., of Cleveland, O. It is made in sizes of ½-cu. yd. to 2 cu. yds. capacity, and the weights are about 425 lbs. and 800 lbs. for the ½-yd. and 1 yd. sizes respectively.

Nicholas P. Simin.

By JOHN C. TRAUTWINE, JR.,* Assoc. Am. Soc. C. E.

Mr. Nicholas P. Simin, late Chief Engineer of Moscow, Russia, died at his summer home, near that city, on July 30th last. His death resulted from heart failure, from which he had for some time been suffering, but he was at work, in his office, until within a half-hour of the end.

Some years ago the city of Moscow determined upon the construction of a municipal sewerage system, and it was foreseen that this would increase the demand for water (then only about ten gallons per capita daily), and would render insufficient the supply from wells, upon which, until then, the city had been dependent, and that recourse must be had to the filtration and pumpage of the water of the Moscow River. With this in view, Mr. Simin, in 1897, made an extensive tour of Europe and America, gathering information needed in the development of the necessary works. Upon this tour he was accompanied by his daughter, Miss Olga Simin, who, having acquired the necessary knowledge of English, acted as her father's interpreter and amanuensis.

The new works, designed and built by Mr. Simin, and costing $3,000,000, were begun during the summer of 1901, and, in December of the same year, the river water was being sent to Moscow through a 36-in. main, about 14 miles long. The work embraced reservoirs and covered slow filters, and a rapid filter plant was built for experimental purposes.

The entire system, planned by Mr. Simin, would have cost $9,000,000; but, owing to differences of view between himself and the municipal government, Mr. Simin withdrew from the service before the close of 1903. Respecting this, he wrote: "I lost 7,000 annual dollars and shall soon have to leave the beautiful house where we live * * *, but I have received instead a profound inward peace, based on the fact that I shall have no more to fight with the city councils, which was my chief occupation during 28 years."

Since his retirement from public service, Mr. Simin has been actively engaged in water-supply engineering. He has contributed to the American Water Works Association papers respecting fire protection, the purification of water by means of ozone, and the new Moscow water-supply system.

Mr. Simin leaves a widow, two sons and three daughters. Both sons, graduate civil engineers, have been actively associated with their father in his engineering work, which included the installation of works for water supply and fire protection at Tobolsk, Siberia, the first works of the kind ever built in that country. The second son, Boris, has taken post-graduate courses in physics at Cornell and Johns-Hopkins Universities; and Olga, with the assistance of Boris, translated, elaborated and published Professor Joukovsky's account of his experiments, at Moscow, upon water hammer.

Another daughter, after graduating in medicine at Zurich, married Mr. Anatol Semenoff, District Engineer of Perm, Russia, and the third daughter is a student of chemistry and biology, with special reference to water supply.

Those who had the good fortune to meet Mr. Simin during his only visit to America will long remember his courtesy, his good humor, his wholesome presence. His attitude toward his secretary-daughter suggested that of an elder brother, rather than that of a father. He who had fought with councilmen at Moscow had the playfulness of a schoolboy.

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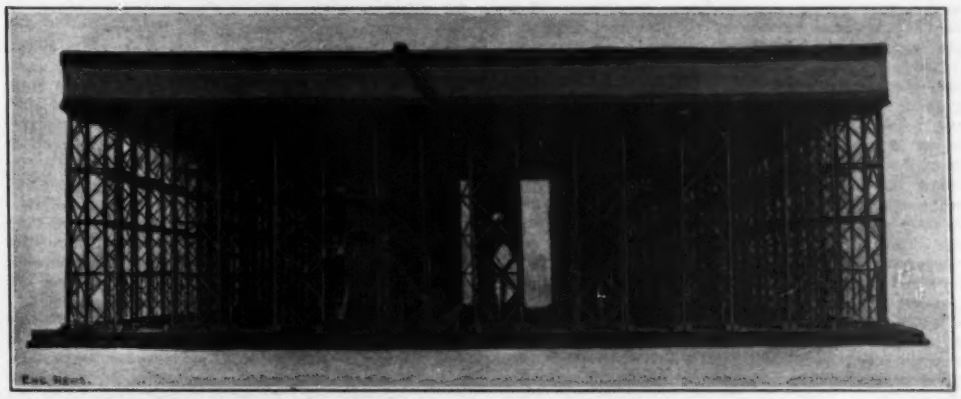
A Monster Elevated Water Tank at Calcutta.

Not with the idea of recommending the design to American engineers, but, rather, to illustrate the peculiarities of antipodean construction, we reproduce herewith, from the London "Engineer," July 9, 1909, a view of a model of the huge elevated water tank now under construction for the Corporation of Calcutta, India. The following description is taken from the above-named journal. The tons there used are the English long tons of 2,240 lbs.:

The tank, which has been designed by Mr. W. B. MacCabe, M. Inst. C. E., Chief Engineer to the Corporation, will have a capacity of 9,000,000 gals., or nearly 40,200 tons of water, and will involve the use of approximately 7,000 tons of steel work. It will be 321 ft. square, 16 ft. deep, and will be divided by cross frames into four equal compartments, which can be used independently of each other, so that one or more compartments can at any time be thrown out of work for repairs or cleaning without interruption of the supply to the town. To give the necessary head the tank will be supported on steel columns, the height from the top of the reservoir to the ground level being fixed at 110 ft., giving a water pressure of about 47 lbs. per sq. in.



MODEL OF A 9,000,000 -GAL. STEEL WATER TANK TO BE ERECTED AT CALCUTTA, INDIA.

The illustration is from a photograph of a model of the tank, and shows the means by which it will be supported. There will be 81 of the supporting columns, each composed of four rolled steel beams, braced together at intervals by smaller beams, and each trestle will carry cross beams at the top to support a 20-ft. section of the tank floor. Provision for expansion and contraction of the tank will be made by making the bottom flexible, so that the only effect of changes of temperature will be that the slight sagging of the bottom which will take place between each pair of the supporting joists will slightly increase or decrease as the temperature rises or falls. The 60-in. pipe, which will act both as the inlet and outlet branch, will be fitted with an expansion joint, while to protect the water from contamination and to keep it cool the tank will have a flat terrace roof consisting of 2½ ins. of fine concrete carried on slates laid between steel rafters. These in turn will be carried on steel joists supported on steel columns from the bottom of the tank. To make the roof water-tight a sheet of bitumen will be laid over the whole area between the slates and the concrete, and to prevent birds entering the tank through the ventilating spaces all means of ingress will be closed by brass wire netting.

The maximum load on each vertical member of the substructure of the tank will be 200 tons, thus giving a total load of 800 tons on each of the sets of four braced verticals. Under each member will be a shoe for distributing the load on the surface of the concrete to 6 tons per sq. ft. The load on the soil under the concrete foundations will only be about 0.6-ton per sq. ft., leaving a margin of safety even in bad ground such as exists in Calcutta.

The foundation at the Tallah Works where the tank is to be erected is a separate contract, and is on the grill reinforced concrete system. It consists of a bed of concrete 2 ft. 6 ins. thick, reinforced at its base with a system of flat ties crossing each other at right angles beneath the supporting columns. Near the surface of the concrete bed a system of steel joists is to be built in, corresponding exactly to the system of flat ties below and upon these joists the bases of the columns will rest. The whole foundation forms a system of which the ties become the lower or tension members, and the joists and concrete take up the compression, spreading the weight over the whole area of the foundation. As an additional precaution a dwarf wall is to be constructed completely surrounding the foundations, and extending from the surface of the concrete to a depth of 4 ft. below the foundation level. This wall will also be of concrete reinforced with expanded metal.

The tank forms part of a scheme to afford a present supply of 32 million gallons of filtered water per day, with provision for ultimate extension to 40 million gallons. The water will be raised up into the elevated reservoir by Diesel oil engines and pumps capable of delivering one-third of a million gallons per hour against a head of 125 ft.

It is being fabricated by the firm of Clayton, Son & Co., of Leeds, Eng.

Difficulties in the Practical Work of Creosoting Timber.*

By CAPT. JOHN C. OAKES, U. S. A.†

The use of creosote for the preservation of timber is daily becoming of more importance as the scarcity and cost of timber increases. There are many methods of treating timber with creosote, all of more or less value according to circumstances, but the one known as the "Bethel dead oil of coal tar process," or the "Pressure process," is of greatest value and is the one generally meant when the term "creosoting" is used. Other creosoting methods are generally designated by some descriptive words, as "Open tank," "Brush," "Rueping process," etc.

RUEPING PROCESS.—This last mentioned process is recommended for light treatment only, and its value is, up to the present time, unknown. It should have some value, and experiments now being carried on in various parts of the country, notably by the Atchison, Topeka & Santa Fe Ry. Co. in connection with the protection of railroad ties, should soon give us data to base conclusions upon. This process consists of subjecting seasoned timber to an air pressure of some 40 lbs. per sq. in. and while the pressure is maintained, allowing the entrance into the tank of the hot creosote and then increasing the pressure to a sufficient degree until the required penetration is obtained. About 15 lbs. per cu. ft. can be forced into pine in this manner. The creosote is then drawn off and a vacuum is created; the compressed air within the wood cells, acting upon the release of the pressure, drives out most of the oil, so that where 15 lbs. per cu. ft. may have been injected, after the oil has been driven out by the compressed air, it will be found that only from 2 to 5 lbs. of oil have remained in the timber.

BETHEL PROCESS.—This process is the one of particular interest at the present time in connection with marine construction, and is the one to which the following statements apply unless otherwise indicated. If proper care is exercised in treating timber by this method, the strength of the fiber of the wood will be practically unimpaired, and the life will be prolonged from 15 to 50 years, according to the amount and quality of oil injected and the uses to which the timber is put. It is the only commercially practical method by which timber may be protected against the teredo, and the amount required to be injected for this purpose at a given locality has in general depended upon the activity of the teredo at that locality. It has ranged from 8 to 10

*From a paper printed in the "Personal Memoirs," Engineer Bureau, U. S. A., April-June, 1909.

†In charge of defensive works at Galveston and of improvements about Galveston Harbor and Channels, Trust Co. Bldg., Galveston, Texas.

lbs. per cu. ft. for northern waters to 24 lbs. for south Atlantic and Gulf waters, the proper requirement for any harbor generally being determined by experience in that harbor or the near vicinity. When heavy treatment is attempted the operation requires judgment and care, and it is owing to lack of such judgment and care that the result oftentimes leaves much to be desired. There seem to be no standard specifications covering the mechanical process among engineers or the firms engaged in this business, and there are no standard specifications in general use for creosote. Besides the unsatisfactory results which may arise from accident, lack of judgment or ignorance, there are also those from improper treatment intentionally given. As a result of the use of oils of different preservative value, and of treatments of varying thoroughness, it is natural that the results should vary greatly, and it is probable that most cases of failure of creosoted timber in marine, or even other work, have been caused by deficiencies of oil or of treatment, or both. The ordinary causes of failure are: insufficient oil; poor oil, either a thin creosote or an adulterated oil; faulty mechanical process, as lack of seasoning, improper steaming, with reference to time or temperature, or both; leaking valves; shortening time of process, or endeavoring to treat unsuitable timber. Most cases are due to insufficient oil, poor oil, or overheating the timber. If the steaming is not sufficient, the oil cannot be injected; if the valves leak, the oil is not injected. Well seasoned and fresh green timber cannot properly be treated in the same charge.

CREOSOTING OPERATIONS.—The actual operation of injecting the creosote is divided into three parts: (1) The steaming of the timber to dissolve and evaporate the contents of the wood cells; (2) the application of a vacuum to empty the wood cells by drawing off the sap and resinous substances, and (3) the injection of the creosote under pressure.

For light treatments air seasoning or hot-air seasoning may be substituted for the steaming process, but in general for a treatment of 14 lbs. per cu. ft. or more the timber is steamed. Besides facilitating the removal of the contents of the wood cells, the steaming, if carried far enough to raise the temperature of the timber throughout above 100° C., sterilizes it and prevents absolutely any deterioration of the timber by rot as long as the outside cells are filled by the antiseptic oil.

As protection against the teredo it is probable that the creosote acts merely mechanically, as it seems the teredo does not bore the wood for food, but rather for a home in which to grow and be protected. Its food is thought to consist wholly of infusoria, which are not obtained from the wood itself. Creosote is to the teredo a disagreeable and possibly poisonous substance in which he will not or can not live. Therefore, where the teredo is active and the waters warm, heavily-treated timber must be used with the object of providing an excess of oil which will during a long period remain within the cellular structure of the timber. The amount of creosote commonly required in the waters of the Gulf of Mexico is 20 to 24 lbs. per cu. ft. In Louisiana, Alabama and Mississippi 20 lbs. is the heaviest treatment usually required. On the Texas coast 24 lbs. is almost invariably required for pine timber, and the Galveston Wharf Co. is now asking for 27 lbs., or what is practically complete saturation. I have known of several cases where over 26 lbs. per cu. ft. have been injected. The statement has often been made that it is impossible to thoroughly penetrate long-leaf pine. This is not correct. Very recently we had occasion to specify 24-lb. treatment for wharf timbers of selected long-leaf heart pine, showing not more than 1 in. of sapwood on one side of any timber. This timber received 25.3 lbs. per cu. ft. without any apparent injury to the timber and showed thorough penetration throughout.

Timber that has been steamed at a pressure of over 35 lbs. per sq. in. should be under suspicion and the pieces should be tested by dropping or subjecting them to bending strains to see that the timber is not "cooked." Even when subjected to pressure under 35 lbs. damage is sometimes done. The injury seems to be of several kinds; the cell walls may be broken down by expansion due to the creation of steam from the sap and water in the cells or they may be charred by too great heat long continued, or they may be broken down by too long boiling.

The timber is steamed for from 8 to 40 hours and when the steam is at last blown out of the cylinder, the vacuum pumps are started. The vacuum is usually held for from 2 to 6 hours, at from 17 to 26 ins. Finally, the preservative is run into the cylinder while the vacuum is held as far as possible until the timber is covered by the oil and the pressure pumps are started and continued until the desired amount of oil is forced into the wood. The amount is generally determined by measurements on the storage tank. Upon completion of the treatment the surplus oil is returned to the storage tanks, the timber is allowed to drip for a few minutes, the cylinder doors are opened, and the treated timber is withdrawn. The process itself as described appears to be a simple one, but there are many things that may be done or left undone which will affect materially the finished product. Before proceeding further it will be necessary to discuss the subject of creosote oil.

CREOSOTE OIL.—One of the by-products of the manufacture of coal gas is coal tar. This is important on account of the numerous and valuable chemicals obtained therefrom.

When coal tar is distilled water passes over holding salts of ammonia in solution and accompanied by a brown, oily, offensive liquid, which collects upon the surface of the water. This is a mixture of the hydrocarbons which are lighter than water. As the distillation proceeds and the temperature rises a yellow oil distils over, which is heavier than water and sinks in the receiver. This oil, commonly called "dead oil," is much more abundant than light oils and amounts to about one-fourth of the weight of the tar and contains those constituents of tar which have a high specific gravity and boiling point, particularly naphthalene, aniline, quinoline and carbolic acid. The proportion of naphthalene in this oil increases with the progress of the distillation, as would be expected from its high boiling point, so that the last portions of the oil which distil over become nearly solid on cooling. When this is the case, the distillation is generally stopped, a black viscous residue is found in the retort, which constitutes pitch and is employed for the preparation of Brunswick black and asphalt for paving.—(From Bloxam's Chemistry, p. 774.)

The point at which the distillation ceased will, of course, determine the ingredients of both the pitch and the dead oil. In America there is practically no market for the hard pitch, but there is a market for the soft pitch for roofing. Therefore, American oils generally will be lighter than the English oils and will contain very little, if any, of the high-boiling oils. English oils, on the other hand, contain a large percentage of the heavier and higher-boiling oils.

After the extraction of the chemicals from this "dead oil," which are commercially valuable, as aniline, carbolic acid, and sometimes naphthalene and anthracene, there remains the commercial oil "creosote." It will, therefore, be seen that the oil sold as creosote is that portion of the dead oil of coal tar left over after those hydrocarbons that are commercially valuable are taken out. Mixed with this residue or refuse oil may be other chemicals, which were used in the process of extracting some of the valuable hydrocarbons. If the creosote is obtained from works where the carbolic acid is extracted, the oil will have a low percentage of "tar acids." If naphthalene has been extracted, the oil will be low in that quality, and if roofing pitch has been manufactured, there will be almost no anthracene, because the distillation ceased before the oils containing anthracene were distilled over. Varying as commercial creosote oils do, their preservative value must also vary greatly.

There are also other oils on the market which are mixed with coal-tar creosote or substituted therefor, as crude petroleum, oil from Mond-producer tar, oil-gas tar, etc. There are many opinions as to the value of these oils as preservatives. Chemists do not agree as to the value of the various oils or the ingredients thereof, and engineers therefore are at a loss when making specifications. At one time it was thought that creosote should have a large percentage of tar acids. A series of experiments by Mr. Coisne, an engineer of the Belgian Government, showed this idea was incorrect.

It has also been thought that naphthalene was the most valuable preservative constituent of creosote. The adherents of the "naphthalene theory" claim that the protection is gained by the volatilization of the lighter oils which disinfect the water that enters the wood, and thereby kill the micro-organisms that would otherwise find a lodging, and that a heavy oil would not do this so readily. They cite the fact that the oil now found in wood, well preserved for many years, is lacking in light oils (and naphthalene) and contend that the very loss of them is what has protected the timber. Many experiments have been made to determine the truth of this, but the results have not been definite, and it is still a disputed question. Some firms and corporations specify a definite amount of naphthalene, because oils that have been proven successful with them had that amount. It is doubtful, however, if the requirement that there shall be a definite amount of naphthalene in the oil does not result in obtaining a poor oil.

Some people claim that the crystalline naphthalene acts as a stopper in the wood cells to hold the liquid in. I do not believe this, for I have found that oils high in naphthalene dry out of the timbers rapidly, while oils having a large portion of the high-boiling constituents remain in a long time, due to the solidifying of the heavy oil in the outside cells and the deposit of pitch over the surface of the timber.

The analysis of some forty specimens of creosoted timber that had successfully resisted the elements and marine borers for a number of years, made by Prof. Gellert Alleman and published in Circular No. 98, Forest Service, Department of Agriculture, shows that of the ingredients remaining in the timber the anthracene and higher boiling oils represented the largest percentage. It is logical that this should be so, because the lower boiling oils are the readiest to volatilize and disappear.

The opinion is becoming more prevalent that the higher boiling oils are the important ones; the "trade" considers as best the creosotes containing the high-boiling oils with a large percentage of anthracene.

The idea that naphthalene is the most important ingredient in the oil has been, however, very prevalent, and that idea has led to the requirement in specifications that a large percentage of naphthalene should be present. Some specifications require as high as 40%.

In a case that has recently come under my observation the oil used was not what is considered by the trade as a first-class creosote oil, and, on objection being made to it, the firm replied that they had to buy that quality of oil in order to comply with certain specifications, and showed several, some of them Government specifications, that did practically require an oil like the one in question. One case is known where an oil was rejected because it had not sufficient naphthalene. The oil was undoubtedly a poor oil, but should, in my opinion, have been rejected for other reasons. One Government specification at hand allows 25% to be distilled over below 210° C. and does not designate the inferior limit, but, I suppose, 170° C. would be understood. Another specification at hand requires 8 to 10% distillate below 200° C., exclusive of water.

In my opinion, that portion of the oil that distils over below 210° C., and certainly below 200° C., is lost from the timber very soon after it is removed from the cylinder, and, consequently, to require any proportion of the oil to distil over below 200° C. is to require that just that proportion be furnished in order that same may be immediately lost. The requirements mentioned above could not have been complied with by what is considered as a first-class creosote oil. The best English creosote oils will not comply with these requirements, and in consequence American oils which are deficient in high-boiling constituents or foreign adulterated oils would have to be furnished.

The Forest Service has published Circular No. 112, "The Analysis and Grading of Creosotes," which is of particular interest in this connection, and to which the readers of these remarks are referred for more technical information.

Distillation Tests.—In most specifications the composition of the oil is specified in one of two ways, viz., by designating the percentage of certain compounds, or by specifying the percentages of distillates, between certain temperatures.

In using this latter method the manner in which the distillation is to be made must always be designated, because analysis of the same oil by different chemists, or even by the same chemists, will show greatly varying results, owing to the different methods and different apparatus employed.

Besides the errors due to inaccurate thermometers, to cooling the thermometer stem and to non-representative samples it has been found that different results are obtained, due to the shape and capacity of the vessel used in distilling the oil; due to the rate at which the distillation takes place; and last, but most important of all, due to the position of the thermometer bulb, whether in the oil, just above the oil, or just below the outlet tube.

The method common in England is to place the thermometer directly in the oil, generally ¼-in. or ½-in. from the bottom of the flask. In this country it is sometimes specified that the bulb of the thermometer shall be ¼-in. or ½-in. above the liquid.

It is necessary, when indicating an oil by its fractional distillation, that the position of the bulb of the thermometer shall be mentioned. This explains many discrepancies in analyses by different chemists and the cause of misunderstandings between manufacturer and consumer. The first point, therefore, to be determined when a report of a fractional distillation is under consideration is the position of the thermometer bulb with respect to the liquid.

As what we must have is a method that will give uniform results, and with the same oil the same results by all reliable chemists, it would seem that the thermometer should register the temperature of the vapors themselves and not of the oil. If it is placed at some distance above the oil, as in the method recommended by Prof. Gellert Alleman in Circular No. 98 of the Forest Service, the temperature recorded by the thermometer will be more nearly that of the gases passing off, and if the same oil is analyzed a number of times with the thermometer as noted, more uniform results will be obtained than by the other methods. The apparatus as described by Professor Alleman in this circular appeals to me as being more exact and more adapted to obtain uniform results than the apparatus ordinarily used.

The only objection known to the use of the side-neck flask is that the liquid "pops" a great deal and often jumps from the bottom of the flask out through the outlet neck, even though the outlet is 6 ins. above the liquid. This happened during many of the analyses made by the inspector operating under the United States Engineer Office at Galveston, Texas, until he covered the flask with asbestos from top to bottom. The probable cause of the "popping" is the condensed vapor, which on falling back into the oil is again vaporized almost instantly. It is very much worse when a quantity of water is in the oil.

A uniform rate of distillation should also be specified, otherwise the analysis can be manipulated by forcing or retarding the heat. The high-boiling oils will vola-

tilize at a temperature below their boiling point, just as water evaporates below 100° C., or they will not have opportunity to become completely volatilized at their proper temperature if the flame is forced. A rate of one drop per second was used in the method of analysis reported in Forest Circular No. 112, and until some other standard is adopted such rate is reasonable and is recommended. It is also important to divide the range of temperature into certain divisions, so that the distillates obtained throughout the range of a division will have some definite similarity.

Specific Gravity.—Under the present methods employed, the specific gravity of creosote is variously specified for temperatures of 15° C., 38° C., 50° C. and 60° C. As most oils are not completely liquefied at 15° C., and some not even at 38° C., the gravity may be taken at any temperature, and then reduced to 15° C., by using the coefficient 0.0008 for each degree centigrade the temperature of the oil above 15° and adding the product to the observed specific gravity. All things considered it is thought that the specific gravity should be determined at 60° C. If oil at that temperature be compared with water of the same temperature, a more nearly correct specific gravity is determined. Even this is not accurate, because water and oils have different factors of expansion, and therefore if reduced to a temperature of 15° C. they would not bear exactly the above relation.

An oil having a specific gravity as a whole of more than 1.07 should be looked on with suspicion and investigated. Unless it is almost wholly lacking in the low-boiling fractions it possibly has some hard pitch or undistilled coal tar mixed with it.

PRACTICAL OPERATION AT PLANT.—Having determined by analysis that the oil to be furnished for a given lot of timber is satisfactory, it is important to see that it remains so. One of the particular points to be guarded against is the dilution of the oil by the addition of water. As the storage tanks at most plants have open tops and a quantity of water is usually required on top of the oil for fire protection and to prevent evaporation, the oil passing to the treating cylinder may easily carry water with it, particularly as the oil seems to draw down from the center of the tank and sucks the water down the funnel-shaped depression caused by the flow from the bottom of the tank.

Again the oil in the storage tank must be kept heated by steam coils, else the heavier oils will settle to the bottom and become hard and only the light oils and water can be drawn off. If the steam coils leak, water is mixed with the oil. Dilution may also be caused by not cleaning the treating cylinder of condensed steam, saps and resins, obtained from the timber after the steaming and vacuum processes just before allowing the entrance of the oil; leaking of steam pipes in the treating cylinder, etc.; or by using oil that has been previously used in the Rueping process, already described. This process deliberately mixes all of the sap and resinous substances from the wood with the oil. Oil used a few times in this process may become sadly deteriorated and not fit to be used.

Sampling.—During the mechanical operation it is important that the inspector make sure that a fair sample of the oil was submitted for chemical analysis, and for this reason he must be able to make at least a rough analysis to ascertain whether the oil is the same previously analyzed, and, if so, that it has not become diluted. As creosote is a mixture of various oils having different specific gravities, the oils gradually arrange themselves more or less in layers according to specific gravity if stored in a tank whose contents have not been stirred and particularly if unheated. The heavier oils at the bottom become hard and if a portion of the oil from such a tank is drawn off it is very likely that only the lighter oils and water will be withdrawn. For this reason the oil when about to be used should be kept heated to about 80° C. In taking samples from a tank having considerable vertical height a vessel should be used which will enable the inspector to take his sample at any height. Samples from the bottom, middle and top of the tank should be compared and, even while the injection is taking place samples should also be tested that are drawn from the treating cylinder, because at every step of the process, and at every movement of the oil, dilution may take place.

Steaming.—When steam is applied, there is a rapid condensation in the cylinder, due to the cooling action of the cylinder and wood. To prevent this, some plants use steam superheated sufficiently to prevent the condensation. After the condensation ceases, the timber gradually becomes heated and the sap is volatilized from the wood, as are a large part of the resinous compounds, sufficient steam being let into the cylinder to replace the lost heat and take up the additional moisture. If the timber is green and contains a large amount of sap, the cylinder is sometimes blown out several times during the steaming. By far the larger part of the sap constituent of the wood is extracted during the steaming process and passes off as steam and water through valves in the bottom of the cylinder.

The degree of heat necessary to be used is that which is sufficient to volatilize the sap and resinous substances. The more sap in the wood the higher the pressure that can safely be used. For heavy treatment, a pressure of 20 or even 25 lbs. may be insufficient to effect the desired result. I believe the best results are obtained by using 30 to 35 lbs. pressure though 40 lbs. may be needed for green timber, provided it is saturated steam. Superheated steam should never be used even at low pressures, except at the very beginning, when the timber and cylinder are cold. One creosoting company allows a pressure of 60 lbs. on all their work, irrespective of the required treatment. They claim to have steamed paving blocks as high as 80 lbs. without causing deterioration sufficient to be detected, even under such a test as heavy traffic gives them. According to experience of the United States Engineer Office at Galveston, the best results are obtained by increasing the pressure slowly, taking an hour or two to attain the maximum pressure and then gradually decreasing it.

The Vacuum.—The action of the vacuum is perhaps the least understood of the processes connected with creosoting. It is understood, of course, that a certain amount of moisture will be withdrawn, including the dissolved resins, etc., but it is not generally known that most of the moisture is drawn off in a gaseous form and that better results are obtained when the heat is kept up so that the moisture content of the cells may be boiled out under the decreased pressure.

Mr. C. M. Davis, United States inspector under the Galveston office, reported as follows:

> The vacuum seems to volatilize the moisture left in the wood after the steaming process is completed, if the timber is kept heated. At Slidell, La., we obtained the best results by having steam in the cylinder coils while the vacuum was on. The vacuum seems to cause the water in the wood to "boil" and vaporize very rapidly, and this vapor passed out through the vacuum pump. Some was, of course, left in the cylinder and was collected in the "sap cylinder" underneath the treating cylinder, but the amount thus collected was surprisingly small. In the case of a charge of 2,000 cu. ft. of very green pine—so full of sap that it would not float in water—there was less than 1 lb. per cu. ft. collected in this manner out of, possibly, 25 lbs. per cu. ft. extracted.

Injection of Oil.—The vacuum is generally used to accelerate the filling of the treating cylinder with oil. It is very important to have the cylinder filled as quickly as possible, in order that absorption may be as uniform as possible. By proper management of plant the cylinder may be filled in about ten minutes without pumping, but when the arrangement is poor and pumping has to be resorted to it may take an hour or more.

A close inspection of the process of injecting the oil should be made. Improper steaming and vacuum processes show for themselves in the finished product, but a deficiency of oil can not be determined later without expensive investigation. Every source of supply of oil should be gaged before and after treatment. It is not unusual to have connections from the cylinder to several supply tanks and to one or more outlet tanks from which the oil is finally returned to the supply tank. No valve is free from the tendency to leak even under the best of management. Especially important is the correction to be made for change in temperature of the oil in the storage tank before and after treatment. Creosote oil changes in volume approximately 1% for every 12½° C. A thermometer should be attached to the side of the supply tank in such a position that it will not be locally affected by the steam coils, and readings taken before and after the operations and the gage readings corrected for the change in temperature. It is not uncommon for this to make a difference of as much as 4 or 5% in the number of pounds injected.

Absorption.—The amount of oil absorbed before pressure is applied depends on the time taken to fill the cylinder, the grain of the timber, the extent of seasoning and steaming and the viscosity of the oil. It never seems to be uniform even under seemingly the same conditions. High percentages of absorption can be obtained only by using a very hot oil and having the timber thoroughly steamed, possibly oversteamed. Only such oil as is practically free from tar acids should be applied as hot at 88° C., as it is thought that the tar acids affect the structure of the wood materially if the temperature of the oil is too high during injection. In the case of light treatments too great rapidity of absorption is a serious drawback to uniform treatment of the charge. The timber at the bottom of the cylinder absorbs so much more than those at the top that it becomes very noticeable, particularly if a long time is consumed in filling the cylinder. When only the amount of oil is supplied to provide an average treatment for the charge, and the timber is seasoned, the oil hot, and if a long time is employed in filling the cylinder, the bottom timbers may have double the requisite amount and the top timbers practically none.

When different woods are combined in a charge, the less dense get more than was intended and the close grained less than was intended. Cases have been noted where long leaf and loblolly pines were included in the same charge, with the result that the loblolly were saturated and the long leaf received only 3 or 4 lbs. per cu. ft. and only 1 or 1½-in. penetration.

EXAMPLES FROM EXPERIENCE.—A description of a recent experience, in attempting to obtain a good treatment, may be of interest to others.

The specifications for creosoted piles demanded 24 lbs. per cu. ft., the use of a good creosote oil, that the strength of the piles should not be impaired and that they should be protected against the teredo. Realizing that it would be difficult to make specifications that would be fair to both contractor and Government, no effort was made to specify the kind of oil to be used or treatment to be given other than the above, but an affidavit was required of the president or manager of the company that the specifications had been complied with. Upon delivery of the piles their appearance was noted as peculiar, the penetration was found to be slight, and although the affidavit of the manager of the company stated that 24 lbs. per cu. ft. had been injected, upon submitting samples to two chemists, one sample was reported to have 4.8 lbs. per cu. ft. and another sample, which was one of the best penetrated of the piles, contained only 10 lbs. per cu. ft. The analyses also determined that the oil was inferior. Judging from the samples taken, it became apparent that the piles did not contain the necessary amount of oil, notwithstanding that the records of the company showed the treatment and the amount of oil received by each charge as being sufficient to supply an average of 24 lbs. per cu. ft. in the timber treated.

The question as to whether the oil was too light and diluted with water or was lost through some carelessness, leaks, open valves, or whether the reports from subordinates of the company were incorrect, is still to a certain extent an open one. Whatever the causes, the fact remains that the piles did not receive the amount of good creosote oil specified. If they did receive the required weight of the mixture furnished as creosote, the oil was so volatile that more than 50% of it disappeared during the course of from three to six months' exposure. This last supposition can not be accepted, for reasons that to my mind are conclusive, and I was forced to decide that the treatment was deficient.

The company desired to furnish other piles to replace those rejected and wanted to use the same oil which had been reported on adversely by the chemist employed by the Government, still claiming that the oil was "a good oil."

Several analyses were made by well-known chemists with widely varying results. One stated that the oil was not a straight "dead-oil" product and had been adulterated. Another stated that as it existed in the pile, it was a good coal-tar distillate.

The question at once arises as to how to explain the divergence of these various analyses. It was noted that the analyses of the wholesale dealer and the company using the oil, taken from samples before there was much possibility of the oil becoming diluted or adulterated, agreed fairly well, and such divergence as was shown may be readily explained by the fact that the samples were taken from different parts of the storage tank and possibly different methods of analysis used. This oil was an American oil, very thin, and rich in naphthalene. It was, in my opinion, a very poor oil to start with, and further investigation discovered that the chemical constituents varied very greatly from the bottom of the tank towards the top; particularly later, when the oil became diluted with water and possibly with other materials, there was a great difference between the sample taken from near the top and another from near the bottom.

Furthermore, this oil was brought to the plant in a tank steamer that had been carrying crude petroleum, and it is possible that some crude petroleum had been left in the tank of the steamer. There is no telling how much there was left but our analyses show that it is probable that the oil was mixed with petroleum in this way. When this oil was pumped into the storage tank, there was some German oil in the bottom of the tanks.

When we come to the analyses of the oil taken from the samples of piles in question, it will be seen that the analyses by the same chemist of the two different samples vary greatly. The different amount absorbed during treatment, owing to different positions in the charge, may account partly for this, and the varying specific gravities of the ingredients of the mixture may account for part. There was much water in the oil, probably at least 15%, much very light oil and, of course, some heavy oil.

When a mixture like this enters the treating cylinder, it is natural that the heavy oil should settle very rapidly to the bottom and the lighter oil and water to the top. Because of this and the difference in absorption that may take place, the piles of the same charge would receive different amounts and also oils of different specific gravity. Consequently it is not difficult to explain the discrepancy in the quantities of the distillates of oil from the two samples, if we assume a great length of time for filling tank and a very poor oil used that was mixed with water and perhaps other oils or saps. An examination of the piles leads to the conclusion that such assumption is correct.

What are we to think of an oil that is reduced 40 to 50% by volatilization during from three to six months? The fact that the piles were almost as dry as seasoned timber after three months, and could be handled without soiling the hands, leads to the conclusion that the oil was undoubtedly a very poor oil, containing a large proportion of water and probably some crude petroleum, some sap and resin and a large proportion of low-boiling oils. But it is impossible for me to believe that 40 to 50% of true creosote oil, even with a large percentage of water, evaporated in that time. It will, however, be noted that there was no distillate below 200° C. found in the timber by either chemist. This would seem to show again that only the high-boiling oils are valuable.

The piles in question having been rejected, the question of oil was again taken up with the company. A sample of the oil proposed to be used when analyzed showed:

Thermometer bulb at mouth of outlet tube.

	Distillates.	Per cent. by weight.
1.	...° C. to 170° C.	0.85
2.	170 to 205	6.59
3.	205 to 245	53.90
4.	245 to 270	13.05
5.	270 to 320	12.74
6.	320 to 360	8.23
7.	Residue above 360° C.	4.95
		100.40

Small amount of pitch.
Specific gravity, 1.038 at 15° C.
Water, 0.38%.
41.46% solid naphthalene recovered from distillate No. 3.
One-fourth of No. 5 and whole of No. 6 solidified on cooling on account of anthracene present.
Oil contains no impurities; fairly good quality.

This sample was taken by an employee of the creosoting company from the storage tank, evidently from the bottom; and there is a suspicion that the sample may have lost some water and low-boiling oils before being analyzed. At any rate, it evidently was not a fair sample, because after the oil had been brought to the operating plant, put in the storage tanks there and run through the various pipes, etc., a sample of this oil, taken by a Government inspector, was sealed and sent to the Department of Forestry for analysis, with the folowing result:

Specific gravity, 1.0230 at 50° C.
Water content 12.7

	Distillates	Per cent.
1.	...° C. to 170° C.	5.5
2.	170 to 205	9.7
3.	205 to 255	44.3
4.	255 to 295	11.1
5.	295 to 305	2.9
6.	305 to above.	13.3
7.	Loss gas, etc.	.5
		100.0

While waiting for the above analysis, the United States inspector at the plant took one sample from the storage tanks on the dock from which the sample sent to the Forest Service was supposed to have been taken, and one from the supply tanks at the plant after the oil was transferred from the dock to the plant. These samples were analyzed for water and oils distilling off below 170° C. with the following results:

Sample from tanks on wharf:

	Per cent.
Showed water	8.66
Oil distilling off below 170° C.	3.66
Total	12.32

Sample from supply tank at works:

	Per cent.
Water	21.20
Oil distilling off below 170° C.	6.30
Total	27.50

The oil was rejected, as they were unable to free the oil of water.

Here again we find a vast discrepancy shown by the analyses. There is no doubt that the samples were taken from a supply of oil pumped into the storage tanks at one time from one vessel, and the only way to account for the discrepancies is that the first sample taken by the company was taken from the bottom of the storage tank after the oil had been undisturbed for a long time and had had time to arrange itself in layers according to the specific gravity of the various ingredients. The Government inspector stated that the oil at the bottom of these tanks before warming was practically solid. The light oils and a quantity of water which was mixed with the oil, or was possibly on top of the oil, was carried to the operating plant and was there evidently mixed with oil, water, sap and resin in the pipes and the tanks at the plant.

From the above experience it is very evident that the oil question is a very serious one. First it is essential to determine the kind of oil required. Second, it is necessary to see that an oil that complies with the specifications is used.

Conclusions.

For marine work and heavy treatment of 20 (or more) lbs. per cu. ft. of timber, the following points should be specified.

Oil.—Should be of the best English coal-tar creosote oil or its equal without admixture of other oils or substances not derived from the distillation of coal tar. Its relative gravity at 60° C. compared to water at the same temperature should not be less than 1.04. It should contain not more than 3% water, the percentage to be compensated for in computing amount of oil to be injected; not more than 5% should distil below 210° C. and not more than 25% below 235° C., when analysis is made by Forest Service method (see Circular No. 112). Not more than 5% tar acids should be allowed in oil. Oil should be at same temperature in tanks when measurements are made before and after the operation, or shrinkage due to change of temperature should be allowed for; oil should be kept hot during treatment, a temperature of 80° C. recommended. Allowance should also be made in computations for expansion of treating cylinder under pressure.

Fair Samples for Analysis.—Oil should be completely liquid when sample is taken, and if drawn from tanks a number of samples at different heights should be taken and averaged. If taken while oil is being transferred, a drip sample taken from cock in line is desirable.

Dilution.—Inspector should watch closely all means of dilution, and make sure none has occurred by analyses of oil taken from treating cylinder during process of injection.

Charge.—Should be uniform as to kind, cross-section, density and moisture content.

Steaming.—Duration and intensity of steaming should be left to management of plant on account of varying equipment at different plants, varying density, etc., of timber from different localities; however, specifications should provide that treatment shall not injure fiber of timber, nor impair strength appreciably.

Vacuum.—Same as for steaming, with the additional requirement that cylinder and contents should be kept hot during process by steam coils in cylinder.

Absorption.—To do good work a plant should be properly equipped for filling treating cylinder quickly to avoid different degrees of absorption, which tends to overload some of the charge while the remainder does not receive the required amount.

Pressure.—Should be continued until gages show that a little more than the computed amount of oil is injected to allow for dripping and release of oil while cylinder is being emptied of the surplus oil and for the expansion of the cylinder under pressure. The cylinder doors should be opened promptly and the charge withdrawn as soon as possible.

Inspection.—Specifications should contain a clause requiring the management of a plant to furnish the inspector every facility requested by him for measuring timber, oil, tanks, cylinders, etc., and for taking and analyzing oil samples as often as deemed necessary, including use of a laboratory and such apparatus as he may require.

Inspector.—He should have sufficient knowledge of the chemistry of creosotes and skill to make the necessary analyses and should study the plant carefully to prevent mixing of water, bad oil, etc., left in pipes, tanks, cylinders, etc.

For light treatment the same considerations should govern as for heavy treatment, except that the oil need not be heated to 80° C., the water content may be allowed as high as 8% all to be compensated for, and more care must be exercised to obtain uniform absorption in order to obtain uniform results.

I desire to acknowledge indebtedness for information obtained from the various publications of the Forest Service relating to this subject, and also for the valuable articles with discussions published by the American Railway Engineering and Maintenance of Way Association, and to other available literature bearing upon the subject. I am also indebted for valuable assistance to Mr. C. M. Davis, United States Inspector under the Galveston Engineer Office, who was present at the plants during the creosoting of the timber supplied under contract with that office during the past six months.

PARIS-NEW YORK CITY WIRELESS communication is now reported by Capt. Ferie, in charge of the temporary radiotelegraphic station of the French Government at the Eiffel tower, Paris. The present communication is not at all regular and probably will not become official or commercial.

The Coal Mining Industry of the United States in 1908.*

DECREASE OF PRODUCTION FROM 1907.—The history of the coal-mining industry in 1908 was in marked contrast to that of the preceding year. During 1907 the production of both anthracite and bituminous coal reached the highest point ever recorded. Until October the demand in all parts of the United States had been of a record-breaking character and the production seemed to be limited only by the inability of the operators to procure adequate labor and transportation facilities. In addition to this, there were few instances of labor disaffection, and what time was lost was insufficient to affect the total production. The record made in 1908 was in striking contrast with these conditions.

There were three influences producing this notable change. First and most important was the financial disturbance commencing in October, 1907, and continuing through 1908. The second influence was the general suspension of operations on April 1, 1908, in the bituminous regions, pending adjustments of wage scales. As wage agreements were already in force in the anthracite regions there was no general suspension among those workers. The third depressing influence was the protracted drought in the Eastern and Middle States, which began early in the summer and lasted well into the winter months. In Arkansas, Kansas, and Oklahoma the coal production was influenced less by the financial conditions than by the competition of coal with fuel oil and natural gas from the mid-continent and Louisiana fields. A short cotton crop, and consequently lessened demand from ginning establishments, also adversely affected the coal production of these states.

It will be seen from the accompanying table that the 1907 production, 980,363,424 tons, was reduced to 415,842,698, a drop of 13.43%. This was accompanied by a drop in value of 13.42%.

The fact that the percentage decrease in value was insignificantly different from that in production is notable in the face of the demoralized trade conditions, and was due in part to the necessity of maintaining prices, because operations in most of the important producing states are carried on under agreement with the United Mine Workers of America and there was no cut in mining wages, so that the cost of mining was relatively as high as in the more prosperous years of 1906 and 1907. Another reason for the slight falling off in value was the fact that on account of the trade conditions consumers were more exacting in their demands than they were in 1906 and 1907, when operators were able to market practically all the coal they could mine. This caused a larger percentage of slack and other salable coal to be thrown on the dumps in 1908, so that the returns to the operators were considerably less than appears in the statistical record.

Of the 30 states and territories which produced coal in 1907 and 1908 only three—California, Oregon and Texas—increased their output in the latter year. The increases in the first two were unimportant. The increase in Texas was due in part to the continued decrease in the production of petroleum in the state, to the rapid growth of population, and to the comparatively prosperous conditions which prevailed. Utah was

*Condensed and rearranged from information furnished by the U. S. Geological Survey, contained in advance notes on a report by Mr. E. W. Parker.

PRODUCTION AND VALUE OF COAL IN 1907 AND 1908, BY STATES AND TERRITORIES, WITH INCREASE OR DECREASE IN 1908.

	Production (short tons)				Value.			
State or Territory.	1907.	1908.	Increase (+) or decrease (—), 1908.	Per cent.	1907.	1908.	Increase (+) or decrease (—), 1908	Per cent.
Alabama	14,250,454	11,604,593	— 2,645,861	....	$18,405,468	$14,647,891	— $3,757,577	....
Arkansas	2,670,438	2,078,357	— 592,081	....	4,473,693	3,499,470	— 974,223	....
California and Alaska	24,089	21,862	— 2,227	....	91,813	69,650	— 22,163	....
Colorado	10,790,236	9,634,973	— 1,155,263	....	15,079,449	13,586,988	— 1,492,461	....
Georgia	362,401	264,822	— 97,579	....	499,686	364,279	— 135,407	....
Idaho	*7,588	5,429	— 2,159	....	*31,119	21,832	— 9,287	....
Illinois	51,317,146	47,659,690	— 3,657,456	....	54,687,382	49,978,247	— 4,709,135	....
Indiana	13,985,713	12,314,890	— 1,670,823	....	15,114,300	13,084,297	— 2,030,003	....
Iowa	7,574,322	7,161,310	— 413,012	....	12,258,012	11,706,402	— 551,610	....
Kansas	7,322,449	6,245,508	— 1,076,941	....	11,159,698	9,292,222	— 1,867,476	....
Kentucky	10,753,124	10,246,553	— 506,571	....	11,405,038	10,317,162	— 1,087,876	....
Maryland	5,532,628	4,377,093	— 1,155,535	....	6,623,697	5,116,753	— 1,506,944	....
Massachusetts	....	50	+ 50	....	....	150	+ 150	....
Michigan	2,035,858	1,835,019	— 200,839	....	3,660,833	3,322,904	— 337,929	....
Missouri	3,997,036	3,317,315	— 680,621	....	6,540,709	5,444,907	— 1,095,802	....
Montana	2,016,857	1,920,190	— 96,667	....	3,907,082	3,771,248	— 135,834	....
New Mexico	2,628,959	2,467,937	— 161,022	....	3,832,128	3,368,753	— 463,375	....
North Dakota	347,760	320,742	— 27,018	....	560,199	522,116	— 38,083	....
Ohio	32,142,419	26,270,639	— 5,871,780	....	35,324,746	27,897,704	— 7,427,042	....
Oklahoma	3,642,658	2,948,116	— 694,542	....	7,433,914	5,976,504	— 1,457,410	....
Oregon	70,981	86,259	+ 15,278	....	166,304	236,021	+ 69,717	....
Pennsylvania	150,143,177	117,179,527	—32,963,650	....	155,664,026	118,816,303	— 36,847,723	....
Tennessee	6,810,243	6,199,171	— 611,072	....	8,490,334	7,118,490	— 1,371,835	....
Texas	1,648,009	1,895,377	+ 247,308	....	2,778,811	3,419,481	+ 640,670	....
Utah	1,947,607	1,846,792	— 100,815	....	2,959,769	3,119,338	+ 159,569	....
Virginia	4,710,895	4,259,042	— 451,853	....	4,807,533	3,868,524	— 939,009	....
Washington	3,680,532	3,024,943	— 655,589	....	7,679,801	6,690,412	— 989,389	....
West Virginia	48,091,583	41,897,843	— 6,193,740	....	47,846,630	40,009,054	— 7,837,576	....
Wyoming	6,252,990	5,489,902	— 763,088	....	9,732,668	8,868,157	— 864,511	....
Total bituminous	394,759,112	332,573,944	—62,185,168	—15.75	$451,214,842	$374,135,268	—$77,079,574	—17.08
Pennsylvania anthracite	85,604,312	83,268,754	— 2,335,558	— 2.73	163,584,056	158,178,849	— 5,405,207	— 3.3
Grand total	480,363,424	415,842,698	—64,520,726	—13.43	$614,798,898	$532,314,117	—$82,484,781	—13.42

*Includes production of Nebraska and Nevada.

exceptional in showing a decrease of 5.18% in the quantity of coal produced, but an increase of 5.39% in value. Massachusetts appeared for the first time as a coal producer, 50 tons of lignite having been mined in Vineyard Haven for local use.

Of the decrease of production of bituminous coal, approximately 30% was in that made into coke. In Pennsylvania alone this figure was slightly more than 42%.

PRICES.—The average price per ton for bituminous coal and lignite was $1.12, 2 cts. less than the average price in 1907 and 1 ct. more than that of 1906. The average price of anthracite at the mines in Pennsylvania was $2.35 per ton long ton in both 1907 and 1908. The average price of bituminous coal is based on all the coal sold or used at the mines, either for coke making or in the mining operations. Only the bituminous coal actually wasted is excluded from the valuation, and this is also not included in the statement of production.

Considerable quantities of both anthracite and bituminous coal are sold at much less than the cost of production. Criticisms are sometimes made on the apparent discrepancy between the prices shown by the averages given in reports of the Geological Survey and those which the public is obliged to pay for fuel. Such criticisms are evidently made in ignorance of the fact that all the profits on mining operations in the anthracite regions are made on sizes above pea coal, and that these sizes represent little more than 60% of the total production. All the sizes below pea coal shipped from the anthracite regions are used entirely for steaming purposes in competition with bituminous coal and are sold at prices considerably below the actual cost of production. In the bituminous regions, particularly outside of the coking-coal fields, a large proportion of the product is marketed as screened coal and much of the slack and other sizes below nut is sold at less than the cost of mining.

INCREASE IN COAL PRODUCTION SINCE 1850.—Attention has often been called to the rapid growth of the coal mining industry and to the fact that in each decade the output practically has been doubled. The year 1908 showed a notable exception to this growth but it is generally considered as only an exception and that the former rates of growth may be expected to return.

The great increase in the production of coal when considered with the increase in population furnishes some interesting comparisons. Going back to the middle of the last century, and comparing the coal production with the population, we find that in 1850 the production of coal amounted to 6,445,681 tons and the population of the country was 23,191,876. The per capita production of coal in that year was thus 0.278 ton. Ten years later the population was 31,443,321 and the coal production amounted to 16,139,736 tons, or an average of 0.514 ton per person. At the census of 1870 the coal production showed a per capita average of 0.96 ton. Ten years later it was 1.52 tons per capita. In 1890 the population had grown to 63,069,756, an increase of 25% over 1880, while the coal production had grown to 157,770,963 short tons, or a per capita output of 2.52 tons. At the taking of the twelfth census, in 1900, the increase in population for the decade amounted to 22%, the total number of persons reported being 76,303,387, while more than 70% had been added to the coal production, the total being 269,684,027 short tons, or an average of 3.53 tons for each inhabitant. In other words, while the population from 1850 to 1900 showed an increase of 230% the production of coal increased 4,084%. The Director of the Bureau of Census estimated the population of the United States on June 1, 1907, at about 85,500,000 persons, making the per capita production in that year 5.6 tons, so that in less than 60 years the per capita production of coal in the United States had increased from a little more than one-quarter of a ton to 5½ tons. If the population of the United States in 1908 is estimated at 87,000,000 persons, the per capita production for that year was 4.78 short tons.

In the earlier years the proportion of wood used for fuel was larger than it is at present, but the actual consumption of wood for fuel is probably as great to-day as it was 50 years ago. It should also be remembered that in addition to the production of coal, there has been a great increase in the use of oil for fuel purposes, and natural gas still remains an important factor in the situation.

EMPLOYEES AND PRODUCTION.—In 1908 there were 600,438 men employed in the coal mines of the country compared with 680,492 in 1907 and 640,780 in 1906. This statement reflects the condition of the labor market. The surplus of labor was general throughout the country, as the increase appeared in most of the coal-producing states, notwithstanding a decreased production. The effect of the business depression is shown in the fewer number of days worked in 1908 as compared with 1907. In the anthracite region the average number of days worked in 1908 was 200, against 220 in 1907; in the bituminous mines the average number of days decreased from 234 to 193. The average production for each man employed was consequently less in 1908 than in 1907, that of anthracite being 478 short tons, against 512 tons in 1907, and that of bituminous being 644 short tons, against 769 tons in 1907. The average daily tonnage for each employee increased, however, that in the anthracite region being 2.39, the largest daily average made since 1903, against 2.33 in 1907, and that in the bituminous regions being 3.34 in 1908, against 3.29 in 1907.

THE USE OF CUTTING MACHINES.—Although the production of coal by machines was less in 1908 than in 1907, there has been a steady increase in the number of machines in use and in the ratio of machine-cut to total coal mined in those states where machines are used. The number of mining machines employed was 6,658 in 1903, 7,663 in 1904, 9,184 in 1905, 10,212 in 1906, 11,144 in 1907, and 11,569 in 1908. The percentages of machine-mined production in these years have been, respectively, 28.18, 28.8, 33.67, 35.1, 35.71, and 37.5. The average production for each machine in use in 1908 was 10,648 short tons, against 12,381 tons in 1907, 11,638 tons in 1906, and 11,258 tons in 1905, the lower average in 1908 being due to the smaller number of days the mines were worked and the consequent decrease in total tonnage.

The total quantity of bituminous coal mined in 1908 by machines was 123,183,334 short tons, or about 37.1% of the production of the country. Of the machines in use in 1908, 6,380 were of the puncher type, 4,992 were chain-breast machines and 197 were long-wall cutters. Pennsylvania led in the number of machines, having 5,103, producing 44.76% of the bituminous coal of the state. Ohio leads in the percentage of machine-mined coal though having fewer machines than West Virginia. Kentucky follows Ohio in percentage of machine-mined coal.

ACCIDENTS.—The Geological Survey compiles its accident figures from reports of state officials, making no attempt to directly collect statistics. However, the states reporting accident statistics produce over 98% of the total coal product of the country, so that the collected figures from these states are a fairly exact index of the extent of injuries and deaths. The year 1907 has the worst record of accidents in the history of coal production in this country. During December there were four separate disasters, all in the Appalachian bituminous coal field and each attended with the sacrifice of many lives. The record made in 1908 was in favorable contrast to that of 1907, but still the number of victims was regrettably large. In the 22 states from which reports were received there were 2,450 men killed and 6,772 injured in the coal mines during the year; in 1907, in the 18 states from which reports were received, there were 3,125 men killed and 5,316 injured.

Comparing these figures with the output, shown in the accompanying table, it is seen that one life was sacrificed for about each 153,500 tons of coal mined. In 1908 this figure was improved to 170,000. Comparing the loss of life to the value of coal mined, it is seen in 1907 one life was lost for each $197,000 value of coal output. In 1908 this was $217,000.

EXPORTS AND IMPORTS.—Practically the entire output of coal in the United States is consumed within the country. The total exports of coal in 1908 amounted to 13,275,558 short tons, which, deducted from the production of 415,842,698 tons, shows a consumption of domestic coal amounting to 402,567,140 short tons. If to this are added the imports, which in 1908 amounted to 1,645,444 short tons, the total consumption of coal in the United States in 1908 (to disregard the stocks on hand at the beginning and end of the year) is shown to have been 404,212,584 tons, which is equivalent to 97% of the domestic production.

Most of the coal imported into the United States is classed as bituminous or shale, only a comparatively small quantity of anthracite being brought into this country. The imports of bituminous coal come principally to points on the Pacific coast and to the port of Boston, where considerable quantities of bituminous slack are imported from Canada to be used at the Otto-Hoffmann coke ovens at Everett. The exports of both anthracite and bituminous coal go principally to Canada.

COAL USED FOR COKE.—The quantity of coal consumed in the manufacture of coke at the mines in 1908 was 32,228,344 short tons, as compared with 50,289,822 tons in 1907, a decrease of 18,061,478 short tons, or 35.9%, as compared with a decrease of 13.4% in the total production. The coal shipped to market and used in the manufacture of coke, and sold locally (which is considered a marketable product) amounted in 1908 to 399,256,861 short tons, compared with 462,802,051 short tons in 1907 and 399,323,294 short tons in 1906.

COLLIERY CONSUMPTION.—The coal used in the mines of the anthracite region of Pennsylvania is principally culm, which was formerly thrown upon the dumps and wasted. In recent years, however, with the establishment of washeries for saving the small sizes of coal produced and also for recovering from culm banks the coal previously wasted, this product has acquired a marketable value. An arbitrary value of 20 cts. per long ton has been placed on the anthracite consumed at collieries, for the figures presented in the accompanying table. The colliery consumption in the anthracite region averages from 8 to 10% of the total anthracite output. In 1908, out of a total production of 83,268,754 short tons of anthracite, about 8,000,000 tons were used at the mines for steam and heat. The colliery consumption of bituminous coal amounts to 2 or 3% of the total production, and in 1908, out of a total of 332,573,944 tons of bituminous coal mined, 8,585,837 tons were used in the operation of the properties.

A BOILER EXPLOSION in a planing mill at Rusk, Tex., Aug. 24, killed three men. Three others were killed Aug. 28 when a boiler exploded in the plant of the Slow Seven Mining Co. at Neck City, Mo. Both accidents are attributed to misreading of the water gage.

AN EXPLOSION OF DYNAMITE at Bocachica, Fla., Aug. 27, killed ten workmen of the construction crew of the Florida East Coast Ry. The accident is ascribed to the carelessness of one of the workmen who threw a lighted cigarette into a box of fuses. When the explosion occurred, according to reports, the men were standing in water 4 ft. deep directly above the charge of 700 lbs. of dynamite.

An explosion of 300 lbs. of dynamite occurred near Freeland, Pa., Aug. 27, when a steam shovel at the Upper Lehigh stripping struck an unexploded charge in a drill hole. Five men were injured. Reports state that the charge had been placed there more than a year ago.

A MINE CAGE FELL 1,500 FT. Aug. 24 in the La Paz mine at Matehuala, Mexico, and 15 miners were killed. Thirty others were imprisoned for some time in the mine due to the disablement of the hoist. Reports state that the brake failed to stop the cage as it neared the top of the shaft and it was brought up against the rafters of the shaft house with a jar that snapped the cable.

The fall of a cage in the British naval colliery at Rhonda, Wales, Aug. 27, resulted in the death of five miners and the injury of 12 others.

AN EXTENSIVE MINE CAVE-IN Aug. 29 at Scranton, Pa., caused an area equal to two city blocks in the western part of the city to sink a distance of from 2 to 8 ft. The houses in the sunken area were thrown from their foundations or otherwise heavily damaged, the total loss to property being estimated at $200,000. One brick building, a public school, was so much damaged that it will have to be torn down. Most of the houses affected were fortunately frame structures. One of these, a three-story tenement house at the edge of the sink, is reported to have slid along about 7 ft. from its original position. Gas and water mains were broken at several points in the disturbed area.

A HEAD-ON COLLISION between a freight and a passenger train took place on the Wabash R. R., Aug. 28, one mile south of Glenwood, Mo. Two persons were killed and 14 others were injured. The freight train, an extra southbound, collided with the northbound passenger, No. 50, while rounding a curve in a cut. Reports state that the crew of the passenger train saw the approaching freight in time to bring their train to a full stop before the crash. The freight, however, continued running at high speed. Both locomotives, the baggage car, one passenger coach and two freight cars were demolished.

A RUNAWAY FREIGHT TRAIN on the Atchison, Topeka & Santa Fe Ry. collided with a Southern Pacific switch engine Aug. 25 at Mojave, Cal. Four men were killed and four others injured. The heavy freight train of 47 cars, eastbound, got beyond control while descending the steep grade one mile west of Warren and six miles from Mojave. When it struck the switch engine in the yards at Mojave, it had attained a speed of about 40 mi. per hr. The two engines and 39 of the freight cars, were piled up in a heap in the yards.

AN ARGENTINE EXCURSION STEAMER SANK Aug. 24 at the entrance of Montevideo Harbor, Uraguay, South America, after a collision with the North German Lloyd liner "Schlesien." More than 150 persons were killed by the collision or drowned when the vessel sank. Although there were a large number of women on board, most of the 70 persons rescued were men. The accident occurred at six o'clock in the morning in a driving rain. The excursion steamer "Columbia" was entering port with about 200 passengers and a crew of 48 men and the "Schlesien" was outward bound for Bremen. A high sea made the ships difficult to manage and they came together with sufficient force to crush the "Columbia's" bow. She sank almost immediately.

DELUGE AND FLOOD AT MONTEREY, Mexico, produced great loss of life and property damage during Aug. 28 to 30. Estimates are made of a thousand dead in Monterey and another thousand in the nearby territory. Press dispatches say that 21¼ ins. rain fell in 72 hrs. at Monterey. The Monterey storm was the worst incident of a Gulf hurricane that did much damage along the Mexican coast, among which was wrecking the light-

houses and part of a jetty at Tampico. Telegraph wires, railway roadbed, etc., were extensively injured in the northeastern States from Coahuila down to the Isthmus of Tehuantepec. The intense rainfall at Monterey caused a rapid and extremely high flood rise in the Santa Catarina River, which overflowed the lowlands and swept away a large section of the poorer part of the city. The floodwave passing thence down the San Juan River to the Rio Grande threatens to do damage along the lower reaches of the latter stream, according to advices of Aug. 31 from Sam Fordyce, Tex., where the rise had reached 36 ft. on that date.

A NEW ZEPPELIN AIRSHIP, the third of this type of huge rigid dirigible balloons, dubbed "Zeppelin III.," journeyed from the Zeppelin works at Friedrichshafen, on Lake Constance, Germany, to Berlin on Aug. 29. Count Zeppelin was received by the Emperor, who introduced Mr. Orville Wright, the American inventor. On the return from Berlin, the following day, the forward propellers were broken and flying fragments ripped open one of the forward gas compartments. The ship was brought down gently and moored in a meadow until repairs could be made. These were completed in two days.

THE AVIATION MEET at Rheims, France, ending Aug. 28, produced a small crop of new aeroplane records, as was expected. None of these records was of particular significance, however, in comparison with those just previously established.

Glenn H. Curtis, representative of the Aero Club of America, won the Gordon-Bennett International Trophy on Aug. 28 by making 20 kilometers (12.42 miles) in 15 min. 50 3/5 sec., or a speed of about 47.5 mi. per hr. On the following day, in competing for the Prix de la Vitesse, he made 30 kilometers (18.63 miles) in 25 min. 49 2/5 sec., or a speed of 43.3 mi. per hr. This included a penalization of one-tenth, however, so that the actual speed was about 47.7 mi. per hr.

Henri Farman, of Paris, won the Grand Prix de la Champagne of $10,000, and established a record, for a sustained flight, of 3 hrs. 4 min. 56 2/5 sec. The official record is for 111.78 miles but this aviator remained up some ten minutes after 7.30 p. m., after which hour the judges refused to credit his performance. An extra 10 kilometers was thus unofficially covered making the real, but unofficial, record 118 miles in about 3 hrs. 15 min.

Hubert Latham, of Paris, won the Prix de l'Altitude, reaching a height of some 490 ft.

NEW YORK TO LONDON in 5 days 9 hrs. 22 mins. from dock to railway station is the record established in connection with the eastward voyage of the Cunard liner "Mauretania," making Fishguard, Wales, a port of call. The cabled reports credit the ship with a run of 2,807 miles, to a point called Brow Head, in 4 days 14 hrs. 27 min., presumably timing from the Sandy Hook lightship. This gives an average speed of 25.41 knots per hour which applied to the course usually reported, between the Sandy Hook lightship and Daunt's Rock, 2,783 miles, would give an equivalent run of 4 days 13 hrs. 24 min., which would be the transatlantic record. Passengers booked for Paris made a record of 5 days 19 hrs. 49 min. from the New York dock to the Gare du Nord. The railway trip from Fishguard to Dover was made via London, but it is expected that in the future a connection will be made with the Southeastern Railway for Dover at Reading, thereby saving time.

A FURTHER TUNNELING RECORD was made in the Loetschberg Tunnel in July, 1909, according to the month's statement as given in the "Schweizerische Bauzeitung" of Aug. 21. The North heading made an advance of 309 m. (1,013 ft.), working four Meyer (air) percussion drills, progressing in limestone. There was an interruption of 32 hrs. in commemoration of the disastrous cave-in of July 24, 1908. The working time therefore was about 29¾ days.

The South heading during July advanced 156 m. (512 ft.), working in varying rocks including quartz porphyry, granite and gneiss. Five to six Ingersoll drills were used.

MUNICIPAL EXPENDITURES OF CHICAGO are to be investigated by a local committee of eleven, appointed by Mayor Busse. The membership of the committee includes Mr. Charles E. Merriam, Professor of Political Science in the University of Chicago, who is now serving as an alderman of that city; Mr. George G. Tunell, Statistician of the Santa Fe R. R.; Mr. Walter L. Fisher, well known through his activities in behalf of the adjustments of rapid transit matters in Chicago; and Mr. John W. Alvord, M. Am. Soc. C. E.

IOWA COAL IN 1908.—The total coal production in this state in 1908 was 7,161,310 tons, valued at $11,706,402. This was a decrease of 5.45% in amount and 4.5% in value from 1907. There were only three states whose percentage of decrease was less—Kentucky, Montana and Utah. Iowa is almost entirely agricultural, manufacturing not having been developed to such an extent as in some other portions of the country. The farmers were generally prosperous throughout 1908, and the consumption of coal was normal, except for the decrease due to mild weather.

Iowa probably ranks second among the states west of the Mississippi in order of priority as a coal producer. At the time of taking the census for 1840 Iowa and Missouri were the only states west of the river in which any coal production was reported. Missouri, however, was credited with an output of nearly 10,000 tons, while Iowa's production was given at 400 tons. It is probable, therefore, that the first mine opened in Missouri antedated Iowa's initial production.

Iowa's total production of coal from 1840 to the close of 1908 has amounted to 148,770,102 short tons, which, including the waste of half a ton lost for every ton of coal mined and marketed, is equivalent to an exhaustion of 223,000,000 short tons. The original supply is estimated at 29,160,000,000. This would leave about 4,000 times the 1908 production remaining in the ground. If the ratio of waste to marketed coal continues at the same rate, the supply would last 2,700 years at the rate of production in 1908.—From reports of E. W. Parker and M. R. Campbell, U. S. Geological Survey.

Personals.

Mr. J. H. Philips, M. Am. Soc. C. E., has left the engineering department of the Delaware, Lackawanna & Western R. R. to become Chief Engineer of the Essex Co. park commission at Branch Brook Park, Newark, N. J.

Mr. F. H. Alfred, M. Am. Soc. C. E., Vice-President and General Manager of the Canadian White Co., has been appointed Assistant to the President of the Cincinnati, Hamilton & Dayton Ry. Mr. Alfred was Chief Engineer of the Pere Marquette R. R. from 1902 to '05.

Mr. Francis C. Shenehon, M. Am. Soc. C. E., Principal Assistant Engineer, U. S. Lake Survey, has been made Dean of the College of Engineering and the Mechanic Arts of the University of Minnesota to succeed Mr. F. S. Jones who has joined the faculty of Yale University.

Mr. W. I. Baucus, M. Am. Soc. C. E., formerly Chief Engineer, in charge of water supplies, under the U. S. Provisional Government, in the department of public works of Cuba, is now with the U. S. Engineering Department at Large, Boston, Mass. Mr. Baucus has charge of the surveys and investigations for the U. S. Intra-Coastal Waterways Canal from Boston to Narragansett Bay.

Mr. J. E. Woodbridge, recently employed in the railway engineering department of the General Electric Co., has become associated with the firm of Ford, Bacon & Davis, of New York City, and will take local charge of work for this firm in and near San Francisco, Cal., in connection with the completion of the Stanislaus power development and the power supply for the United Railroads of San Francisco.

Mr. R. F. Hayward, M. Am. Inst. E. E., has resigned his position as General Manager of the Mexican Light & Power Co. to become General Manager of the Western Canada Power Co., at Vancouver, B. C., where he will take charge of the construction of a new power plant. Mr. Edward D. Trowbridge will succeed Mr. Hayward as General Manager of the Mexican Light & Power Co. Mr. Hayward went to Mexico City in 1905 from Salt Lake City, Utah, and since that time has been in charge of the completion of the Mexican Light & Power Co.'s hydro-electric plant at Necaxa.

Mr. Henry C. Page, Vice-President and General Manager of the Springfield (Mass.) Street Ry. Co., has been appointed General Manager of the Worcester Consolidated Street Ry. Co., and affiliated lines, with headquarters at Worcester, Mass. He succeeds Mr. E. G. Connette, whose appointment as Transportation Engineer for the New York Public Service Commission was noted in our issue of Aug. 5. Mr. E. J. Dickson, formerly General Manager of the Milford, Attleboro & Woonsocket Street Ry. and of the Uxbridge & Blackstone Street Ry., will succeed Mr. Page as General Manager of the Springfield Street Ry. Co. and his former duties are included in those now assigned to Mr. Page.

Obituary.

Charles Morton, M. Am. Soc. C. E., of Brookline, Mass., died Aug. 28 at his home on Beacon St. in that town. His death came as the culmination of a year of ill health. Mr. Morton was born in Boston, Mass., in 1841, and was educated at the public schools of that city and at Norwich University, of which he was a graduate in the class of 1860. After leaving school, he was first employed on Government surveys in southern Minnesota and northern Iowa, and later, returning to the East, took part in the work on the Boston Back Bay improvement. From 1865 until 1885 he served in the offices of the Boston City Engineer and City Surveyor. Since then he has been successively Acting and Deputy Superintendent of the Boston street and bridge departments, 1886-'87; Superintendent of the Boston Heating Co., 1887-'89; Superintendent of Sewers (Boston) 1889-'91. In 1891 he was appointed a member of the Board of Survey of the city of Boston and he remained in this position for several years. He is survived by his wife, who was formerly Miss Annie H. Hunt, of Dorchester, Mass.

Engineering Societies.

COMING MEETINGS.

TRAVELING ENGINEERS' ASSOCIATION.
Sept. 7-10. Annual convention at Denver, Colo. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 8-10. Annual convention at New York City. Secy., Willard Kent, 715 Tremont Temple, Boston, Mass.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 14-16. Annual convention at Atlantic City, N. J. Secy., Frank P. Foster, Corning, N. Y.

MICHIGAN GAS ASSOCIATION.
Sept. 14-17. Annual meeting on board steamer sailing from Detroit, Mich. Secy., A. P. Ewing, Gas Office Bldg., Detroit, Mich.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION.
Sept. 14-17. Annual convention at Washington, D. C. Secy., Walter E. Emery, Peoria & Pekin Union Ry., Peoria, Ill.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 14-17. Annual convention at Niagara Falls, N. Y. Secy., A. P. Dane, Boston & Maine R. R., Reading, Mass.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Sept. 16-Oct. 12. Annual convention and excursion on special train starting at Chicago, Ill. Secy., R. W. Raymond, 29 W. 39th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.
Sept. 25-27. Annual convention at New York City. Secy., P. S. Millar, 25 W. 39th St., New York City.

AMERICAN MINING CONGRESS.
Sept. 27-Oct. 2. Annual session at Goldfield, Nev. Secy., J. F. Callbreath, Jr., Denver, Colo.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.
Oct. 4-8. Annual convention at Denver, Colo. Secy., Bernard V. Swenson, 29 W. 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 12-14. Annual convention at Louisville, Ky. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 19. Annual convention at Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine R. R., Concord, N. H.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 19-22. Annual convention at Richmond, Va. Secy., Chas. O. Probst, Columbus, Ohio.

AMERICAN GAS INSTITUTE.
Oct. 20. Annual meeting at Detroit, Mich. Secy., A. B. Beadle, 29 W. 39th St., New York City.

AMERICAN MINING CONGRESS.—At the twelfth annual session in Goldfield, Nev., Sept. 27-Oct. 2, committee reports will be presented on the following subjects: "Vertical Side Line Law," chairman, Geo. W. Riter, Salt Lake City, Utah; "Coal Tax Insurance Fund," chairman, S. A. Taylor, Pittsburg, Pa.; "General Revision of Mining Laws," chairman, W. R. Ingalls, New York City; "Standardization of Electrical Equipment," chairman, Edward B. Rosa, Washington, D. C.; "Prevention of Mine Accidents," chairman, H. Foster Bain, San Francisco, Cal.; "National Forest Service," chairman, A. G. Brownlee, Denver, Colo.; "Alaskan Mining Laws," chairman, J. L. Steele, Landlock, Alaska. Mr. Moreton Frewen, of London, England; Mr. James J. Hill, and Mr. John Hays Hammond have been invited to speak on the means of bringing about a wider use of silver and decreasing the rate of exchange between the United States and countries using a silver standard.

NEW ENGLAND WATER WORKS ASSOCIATION.—At the 28th annual convention at the Park Avenue Hotel in New York City, Sept. 8-10, papers will be presented as follows: Sept. 8—"The New York Water Supply," Wm. W. Brush, New York City; "Odors and Tastes in the Water Supply of Holyoke," James L. Tighe, Holyoke, Mass.; committee report on "Standard Specifications for Fire Hydrants." Sept. 9—Committee report on "Legislation and Other Matters Pertaining to the Conservation, Development and Utilization of Natural Resources"; "The Poughkeepsie Water Works," John C. Otis, Poughkeepsie, N. Y.; "Water Works Accounting," Harvey S. Chase, Boston, Mass.; "Disinfection as an Adjunct to Water Purification," H. W. Clark and Stephen De M. Gage, Boston, Mass.; "Camaguey (Cuba) Water Works," Henry A. Young, Yonkers, N. Y.; committee reports on "Damages Resulting from Diversion of Water" and on "Water-Works Valuation Cases."

On Wednesday afternoon and evening (Sept. 8), a trip will be made to Coney Island; Thursday afternoon there will be a visit to the Pennsylvania R. R. terminal and a trip through the Hudson & Manhattan R. R. tunnels under the North River at 28th St. and at Cortlandt St.; Friday, the last day of the convention, will be devoted to a trip to the Ashokan Reservoir now under construction as a part of the Catskill water-supply system of New York City.

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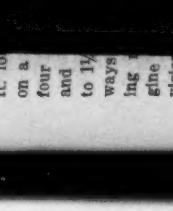

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